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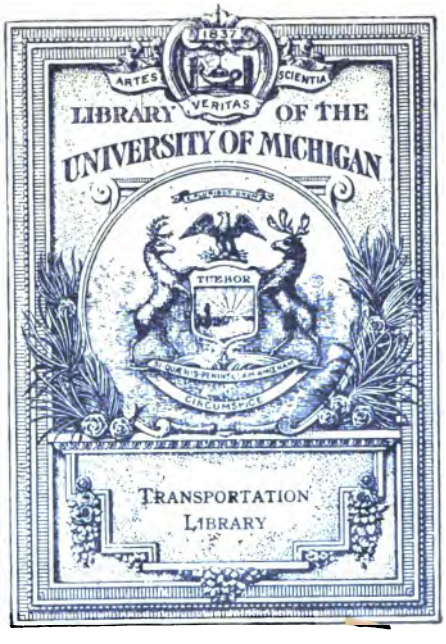
A 753,167 DUPL

RULES, QUESTIONS AND ANSWERS IN NAVIGATION

BY C.S. STREET, D.D.S.



THE GIFT OF
FRANCIS LEE STUART

Rules, Questions *and* Answers

IN

NAVIGATION

by C. S. Street, U. S. N.

The short rules give you a quick method of securing the answers to all the problems used in navigation.

The examples with their answers help you to get the workings of other problems.

There are mistakes, but the methods of each seperate problem will not be wrong by them.

PHILADELPHIA, PA.
1917

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ABBREVIATIONS

Alt. or h... Altitude.
A.M. ..... Morning.
Amp. ..... Amplitude.
A. T. ..... Apparent Time.
Art. Hor.... Artificial Horizon.
Ast. T..... Astronomical Time.
Azi. ..... Azimuth.
Ber. ..... Bermuda.
C. M. G..... Course Made Good.
C.C. ..... Chronometer Correction.
C-W. ..... Chronometer minus Watch.
C.T. ..... Chronometer Time.
Col. ..... Column.
Com. Azi. .. Compass Azimuth.
Cor. ..... Correction, Correct.
Cos. ..... Cosine.
Cosec. ..... Cosecant.
Cot. ..... Cotangent.
Cor. Dec. ... Correct Declination.
Dec. ..... Dec.
Diff. Long . Difference of Longitude.
D.M.G. .... Distance Made Good.
Dep. ..... Departure.
Devi. ..... Deviation.
Diff. ..... Difference.
Dist. ..... Distance.
Diff. Lat. .. Difference of Latitude.
D.R. ..... Dead Reckoning.
E. ..... East.
Eq. T. ..... Equation of Time.
G. or Gr.... Greenwich.
G.A.T. ..... Greenwich Apparent Time.
G.D. ..... Greenwich Date.
G.M.T. ..... Greenwich Mean Time.
G.S.T. ..... Greenwich Sidereal Time.
H.A. or t... Hour Angle.
H.E. ..... Height of Eye.
Hav. ..... Haversine.
H.D. ..... Hourly Difference.
½ Sum..... Half Sum.
Hrs. ..... Hours.
I.E. ..... Index Error.
Lat. ..... Latitude.
L.A.T. ..... Local Apparent Time.
L.M.T. ..... Local Mean Time.
L.S.T. ..... Local Sidereal Time.

Transport

Long.	Longitude.
Log.	Logarithm.
Mag.	Magnetic.
Mag. Azi.	Magnetic Azimuth.
Mid. Lat.	Middle Latitude.
Mer. Diff. Lat.	Meridional Difference of Lat.
M.T.	Mean Time.
M.T. at S.	Mean Time at Ship.
Multi.	Multiply.
Nat.	Natural.
N.	North.
No.	Number.
N.A.	Nautical Almanac.
Obs.	Observation, Observed.
Obs. Alt.	Observed Altitude.
P.D.	Polar Distance.
P.M.	Afternoon.
Pt.	Point.
Pax.	Parallax.
Pos.	Position.
Quad.	Quadrant.
R.A.	Right Ascension.
R.A.M.S.	Right Ascension Mean Sun.
Ref.	Refraction.
Rem.	Remainder.
S.	South.
S.D.	Semidiameter.
Sec.	Secant.
Sub.	Subtract.
Sin.	Sine.
T.	Time.
Tab.	Table.
Tang.	Tangent.
Vari.	Variation.
W.	West.
W.T.	Watch Time.
Z.	Zenith.
Z.D.	Zenith Distance.

SYMBOLS

°	Degrees.
′	Minutes of Arc.
″	Seconds of Arc.
h	Hours.
m	Minutes.
s	Seconds.
O	Auxiliary Angle.
Ø	Term.

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A LITTLE TALK ON NAVIGATION

First off, we will say something about the book.

This volume has been published to give information to those who like the problems in navigation and to get more of our yachtsmen interested in off-shore cruising.

The problems are given, where possible, without dates, so that you may work them without having the Nautical Almanacs that the data were taken from.

There will be found mistakes as usual, but the principles of the problems are given in a way that should make them clear. Where the dates are given, you may have to refer to the Nautical Almanacs of the years. They may be gotten from the Government at Washington, D. C.

Be satisfied at first with "near answers," and, should you be an expert calculator, don't holler murder when you find the author has slipped a few seconds. It must be remembered that many of the problems worked while at sea do not take into consideration the seconds. Many of the yachtsmen do not know the compass Deviation and Variation, and they sail from port to port without confidence. This should not be, as the compass when adjusted, or the Deviation known, is one grand toy. With its error known, you have confidence for night-sailing and running, when the sea-smoke comes along.

The New Compass as shown in the book gives you all the points, half points and quarter points, with their respective arc. The outside circle shows the full 360°, and the third circle shows the quadrants. The card is photographed on heavy paper. See ad. back of book. If you wish to have some good evenings plotting Current Lines, Lines of Position and their Crossing, just get a pad of the new Sumner Charts. See ad.

Of course, you can not all have a sextant or chronometer, but that does not keep you from taking an interest in the art of navigation. If you once get interested in this work, you will go without shoes to get a sextant and have a try at old Mr. Sun for your Latitude and Longitude.

This book does not give the worked-out problems, but the "Navigator" and "Useful Navigation," by the author, give them, so that you may see the proper form to set down the figures.

Taking up the sights and their giving absolute correct position, you must not believe the work comes that close. There is a personal error that we all have. Figures are many, and mistakes will creep in. Reading of the sextant after the sight gives another fellow more or less than what you might get. Run of the sea, roll of the cruiser, poor horizon, hot or cold spells, give errors that the tables do not take care of.

The Meridian Altitude sight for Latitude comes within a mile or so; the Longitude sight depends upon the correctness of the Chronometer and the calculation of the run East or West. The Azimuth Tables are correct and will give the True Bearing of the Sun or stars, but you must have a correct bearing from the compass to get the Deviation properly.

Laying down Position Lines on the chart will be in error for small quantities like seconds, and the parallel rulers show error that will make the plotting of the Lines of Position in slight error.

The steering of the cruiser is generally in error, as some men have a strong arm to port, while others the opposite. The run of the cruiser on a long distance without checking up by sights is generally in error, and the Dead Reckoning from the data is seldom correct. Sights of stars are hard to get when the horizon is poor, but a fair position by them is better than none. At early evening or morning the stars may be had for their Altitudes. When the Moon is on the job, the reflected rays directly under her may be used as the horizon. A part of the boat may be used as the horizon, but you will have to take several sights and find out how much to take off the Altitude, or the amount to add, before you can get the proper Altitude. A match may be struck and held at the position you have decided to call your "boat horizon," and a star brought down to it will show a fair result.

For practice you may get one of the boys to row off in a small boat during a dark night, with a lantern, and then use it for a horizon, by bring down the Planets or stars to measure their Altitude.

The Philips Planisphere is one of the most useful star maps, as you may find the stars that will be on your Meridian in a few seconds. The circle may be turned around until dates and time come together, when the position of the heavens will be shown at that time.

From the Planisphere you may soon learn the names of the stars, as they are not given like the old time with signs. See ad.

Just a few words about running the cruisers. Don't get in the habit of letting "John do it." Have a regular system, when off on a cruise, so that the work will not fall on one or two men. Have the boat well equipped with her proper lights, life preservers, anchors and spare-stuff. Load gas on the power boats whenever possible, and keep the tanks full. Get the grub in cases if bound outside for a crack at the navigation problems, and secure fresh foods when on bay or sound cruise each day, and make it a point to get the things you do not get at home.

Mosquito nets should be of copper and kept in place while near shore. Extra anchor should be ready to drop at a second's notice when taking the berth at night, as you can never tell when the run of the sea might make it unsafe.

When the boys come aboard for a trip, "tell them off" into two watches, the Starboard and Port Watches. Decide on one fellow from each watch as the cook, so that grub will be always on hand at the proper times.

If the Starboard Watch has the deck, the cook of the Port Watch is on the job and should feed his watch before their time to go on deck for duty. When the Starboard Watch has been filled up, get some of the bunch to help with the dishes.

Sometimes you may have enough men aboard to have four watches of three hours each. This allows more sleeping.

NAMING THE WATCHES—We might as well commence with this watch as any. It's now 4 P. M. (8 bells), the beginning of the First Dog Watch, which runs until 6 P. M., when the Second Dog Watch begins and is up at 8 P. M. You see, these watches are of two hours each, and they make a change each day, so that the men who go on at 8 o'clock one night will go on duty the next night at 12 o'clock midnight. Then comes the Evening or First Watch, from 8 until 12 midnight. Then the Middle Watch commences, and runs until 4 A. M. Then comes the Morning Watch, which runs until 8 A. M. The Forenoon Watch runs from 8 A. M. until Noon, when the sailor's day commences, after the captain has taken his Latitude sight and declared it is 12 o'clock and calls, "Strike eight bells!" The Afternoon Watch runs from Noon until 4 P. M., which is the time for the setting of the First Dog Watch again. The crew composes the Starboard and Port watches and take alternate charge of the deck.

When you take a sight, be sure you use the proper formula for the results desired.

Meridian Altitude problem used at Noon for the Sun any time a star is on the Meridian, for the Latitude.

Ex. Meridian problem for any time between 26 minutes before or after Noon for the Sun or same time with the stars for Latitude.

Single Altitude and Time problem not more than three hours before or after the body observed is on the Meridian, for Latitude.

St. Hilaire method any time a body may have its Altitude measured for position. When using this method, take the Altitude and sail for some time and then measure the Altitude again and work the problems for position by the crossing of the lines. The Long. problem must be worked up each time. If the run comes about Noon, you may use the Latitude by Ex. Meridian or Noon Sight for the second line of position with this method.

The Sumner method is practically the same, but two Longitudes must be worked at difference of time between them of at least two hours.

The Azimuth and Amplitude problems should be used whenever you get a chance, to make you more proficient with the compass and its error.

Star sights are a blessing, but they can not always be gotten, on account of poor Horizon. Planets give a fine sight, as they are brilliant and can be brought down to the Horizon in dandy shape. You must have the Horizon, however.

Run all courses by Dead Reckoning, and then check up by the sights and change the course to destination, after you have decided you have a good "Fix," as it is called, meaning you are reasonably certain of your position by the St. Hilaire or Sumner methods.

Approaching the land, you will find the horizon a glare of light when cruising in the vicinity of summer resorts, and you may know your position by the dark spaces between the reflected glares.

Coming from Bermuda, we had the entire Jersey beach-lights reflected to us when over fifty miles at sea, and we could tell old Atlantic City, Stone Harbor, Cape May, Wildwood and Holly Beach by the amount of glare and distance of the dark spaces. Of course, this requires local knowledge of these places.

Many of the boys have secured chronometers, sextants and Cole Protractors and have done some very creditable work from their windows. It does not require a thorough knowledge of mathematics to learn navigation. You can master the art by application of the rules, and when you have them down fine, and can take your sight, and come within a mile or so of the proper position, then you can go the next step, and find the makeup of the spherical triangles, if you wish.

A good man with the sextant is not always the best steersman or boat handler, remember, and he should be relieved of duty other than taking care of the Dead Reckonings and taking the sights. In fact, this is enough to take care of.

The compass should be adjusted by such firms as the John E. Hand and Sons Co., 224 Walnut Street, Philadelphia, Pa., but keep tabs on her just the same, if sailing to other ports than your own, as the Deviation changes with the Latitude.

The tables adopted from these problems in this book are the Bowditch Tables, secured from the Government at Washington or from your local nautical dealer. There is some fine reading in the American Practical Navigator or Bowditch, and it can be bought at cost from the Government, with all the tables in it. The tables may be secured separately.

Remember that all the quantities from the Nautical Almanac are for Greenwich Noon, and you must change the quantities that are "on the move" to the time after Noon at Greenwich. The Sumner charts, in pad form, are fine for setting down the lines of position and working the Current Set and Drift. They cannot be beaten for laying down Azimuth lines. See ad.

Using the sextant, don't expect to grab the sun or star the first time, and bring them to the horizon perfectly. It requires a little practice. The reading of the arc also requires some practice. Should you have a friend who has used the sextant, you may get the full swing of the use of same, in a little while, from him.

The Mercator Sailing allows you to find the Course and Distance between two places and is a valuable problem. You may find the Course and Distance between two places from the chart, you know, but when we have a long distance, like a cruise from New York or Philadelphia to Bermuda, then it is better to work by the Mercator problem.

The Middle Latitude Sailing soon shows you the Lat. and Long. in, from the Lat. and Long. left, and is worked for short distances in Dead Reckoning.

The Parallel Sailing is nothing more than sailing true East or West on some one Latitude. The Dist. sailed, is set down as the Departure. To find the Diff. Long. from the Dep. the Dep. is looked up in the Diff. Lat. Column with the Middle Lat. as the Course. Examples of the above in the book.

Time and its many changes get most of the boys rattled for awhile, but they soon get the swing of it, after becoming acquainted with the many times used in navigation.

If you don't see this change of time, get three watches or your watch and two clocks and set them to several times. Say we had 5 A. M. on a certain date, Mean Time or watch time. Set the first clock to Sidereal Time by rules given. Set the second clock to Astronomical Time by adding 12 hours and naming the date one day back. They will all be going then, so that you may see the difference. If you wish to apply Equation of Time to the Mean Astronomical Time, apply the proper Eq. of T. from the N. A., corrected for the G. D. Rules given. This turns the Ast. T. into Ast. Apparent Time.

Now for the Greenwich Date. Don't let this throw you, as there is nothing to it but to apply the Long. you are in to your L. M. T. expressed in the Astronomical form of time. Rules given.

Remember you must have a G. D. for all the problems in navigation, as the quantities from the N. A. are based on Greenwich Noon.

I must say that the correction of the Compass Course to the True Course is better done by the 360° card, as then you do not get mixed in taking the Deviation or Variation the wrong way. "Goes to the left and to the right," means the quantity of Deviation or Variation is changed in these directions. You must get acquainted with the compass card and turn it so that the point under discussion is directly in front of you. Then you will have no trouble in telling which is to the right or to the left. Remember E. means right and W. means left in this work.

Put this under your bonnets: Every time you tackle a problem in navigation, set down every name of the quantities in their proper places. If the Diff. Lat. is north, set it down N., and if the Long. in, is west, set her down that way. Name them all right from the first time you tackle the work and you will be happy ever after.

The taking of the functions from the Bowditch Tables is rather tedious at first, but at that, you soon get the swing of them. Look at the quantity you are to find, and if it does not appear within a small fraction, look at the next minute in the side column and see that if you take the nearest it will, many times, make but a mile's difference. This is not advisable as Interpolation is so very easy for the work you can soon pick 'em out at sight. This Interpolation is nothing more than proportion. The rules in the tables show Diff. for 1' generally. See the examples given and get acquainted with the tables.

Here's hoping you may enjoy the work that so many are taking up at this time.

THE AUTHOR.

EXAMINATIONS FOR YACHTSMEN

The following "Titles" may be given to boat owners, crews of pleasure boats (not paid) and to members of boating organizations who wish to qualify and be rated as men of ability in the art of handling pleasure boats and knowledge of navigation.

TITLES—CREW, NAVIGATOR. The Title, "Navigator," shall be subdivided into three distinct classes as follows:

LOCAL NAVIGATOR, COAST NAVIGATOR, OFF-SHORE NAVIGATOR

To secure one or all of the Titles, a man must have qualifications as follows and pass the examinations similar to those given for each Title. Rules of the Road must be known by all who take examinations.

QUALIFICATIONS—"CREW." Those who make up the crew of pleasure boats during the summer and take part in races or cruises are entitled to ask for examination and be granted the button of qualification, if the examiner is satisfied with answers and ability. They must have attended several of the navigation classes.

Shall qualify as to ability in steering and give experience. He will be required to have taken a trick at the wheel on one long distance race and must know the compass. Attendance in class work required.

"LOCAL NAVIGATOR"—Shall qualify for local section in all subjects, shall have experience with boats at night, shall be known as a boatman in handling, shall know chart-work, lead-line, compass, Latitude, Dead Reckoning, Bowditch Tables (fairly well), Range Lights, buoys and all marks. Class attendance required.

"COAST NAVIGATOR"—Must show two years' duty on pleasure boats in races at sea or of long distance in broken water (to be decided upon by examiner), must qualify same as Local Navigator, shall know Latitude for Noon Sight, Longitude by Chronometer, Azimuth and Amplitudes, Sextant adjustments, Sumner Method and Lines of Position, Soundings in Fog and knowledge of making port in bad weather. Navigation Class must be attended during one Winter.

"OFF-SHORE NAVIGATOR"—Will be examined from list of every subject given for NAVIGATORS and must qualify as a sailor-man with rigging, sails, sea-anchor, knots and splices, small boat handling, deck work, and repairs, all rules pertaining to safety at sea and those of preventing accident by collision. Will be examined in Logarithms, mathematics, use of tables (Bowditch), problems in compass adjustments. Deviation, Latitude and Longitude by Sun or Star or Planet, Single Altitude and Time

problems for Latitude, St. Hilaire Method for Lines of Position, Correction of Chronometer. Rate and Accumulated Rate. Other subjects are to be submitted to the yachtsman if the examiner thinks it best before granting certificate. Men who have not had the experience required by this examination may take same and be given a certificate after serving the required time at sea. One Winter required in the navigation class.

This feature of boosting our sportsmen to better handling and knowledge of seamanship and the art of navigation has been one of the writer's hobbies for years, and it is hoped that some of the clubs may take it up even should the examinations be changed somewhat. The author has five navigation classes for this object.

Some of the questions asked in these navigation classes:

"CREW"

Yachtsmen who answer a similar list of questions successfully may qualify.

1. QUESTIONS: Facing bow of any boat—name the sides.
2. Name the lights that are carried at night for a forty-foot motor boat, sail boat.
3. How much extra cable should be given when anchoring in a tide-way or in hard winds?
4. Can you name the Watches? Give use of the Dog Watches.
5. Name the Eight principle points of the Compass.
6. When do you fly the colors, meaning ensign, club pennant?
7. What is meant by the Sunset Gun?
8. What is required of a good crew after coming to a mooring on a sail or motor boat?
9. What are the fenders for and when should they be taken off?
10. Explain these terms: "Hold her"; "Let go the Hook"; "Snub her"; "Drop the Peak"; "Let the Board Run"; "Come down on the Mainsheet"; "Slack away the Jib sheet"; "Stand by the Topping Lift"; "That will do, men?"
11. Are you afraid to wash the dishes, outside of the boat and decks? Give some method.
12. Do you know how to use the regulation fire extinguisher and life preservers?
13. Can you row or scull a boat?
14. Can you swim?
15. Name one or more boats you have sailed on and give description of her race or cruise.

1. Prove that the Lubber Lines are placed properly.
2. Show that you know that the compass is placed in line with keel.
3. State your knowledge of electric lighting and wiring for the Binnacle Light.
4. Give information about heeling of boat in regards to compass error.

5. How would you find Deviation of a compass that had not been adjusted?
6. Does Deviation change on every point the boat is headed?
7. What makes a compass continually swing?
8. How would you receive an order from the Navigator when you are ordered to the wheel?
9. Do you steer the Compass Course given regardless of obstructions that may be found on your course?
11. Suppose you were ordered on a certain course and had Range Light ahead, would you steer entirely by the compass?
12. Suppose the Range Lights were astern, would you steer entirely by compass?
13. Is there advantage in switching off the Binnacle Light at times?
14. Steering in a seaway and the boat not keeping on her compass course, how would you manage?
15. How would you relieve the wheel?
16. Name the Cardinal, Inter Cardinal, the And points of the compass and the By points.
17. How are the Points of the compass divided?
18. Box the compass in quarter points.
19. Give the degrees, minutes, and seconds of Arc of the eight principle points of the compass, using the 360° circle.
20. Give rules for changing Compass Course to True Course.
21. Show that you can form a Deviation Table on the eight principle points of the compass.
22. How would you know the Deviation of a compass on a certain heading of the boat in daytime?
23. What affects the compass besides the iron in the boat?
24. How near to the required course can you steer in mild weather, if steering-gear is right?
25. Can you favor a boat in a race by steering?
26. Explain Variation of the Compass.
27. How may the Variation be found?
28. Do you know if a boat will have a kicking helm or not?
29. Are you acquainted with the steering apparatus of boats?
30. Give the best equipment for small boats for off-shore work in regards to the steering wheel, quadrant, tiller lines, rudder heads, blades, sheeves, turnbuckles and drums.

31. Suppose you had a boat to take in a race or cruise that had a large reverse bar and lever alongside of the compass. What would you recommend?
32. At night with no compass, Range Lights known and seen, wish to make a certain port. What would you recommend?
33. Give details of compass work when storm hits in and you are cruising or racing up a river.
34. Do you know any way to relieve your eyes from constant strain at night when steering a compass course?

"LOCAL NAVIGATOR"—Questions.

Under this heading PILOT also comes in.

Give your experience with boats and state the waters you have sailed.

1. Name the buoys generally used on our rivers and bays.
2. Name some of the Light Houses on (any river or bay).
3. How would you find out the flashes of any light, light-vessel or light-house?
4. Would you be able to give the Visibility of any light you may meet while cruising?
5. Name the Characteristics of lights used by the U. S. Government.
6. Name the charts best used for location (any location).
7. Plot a Magnetic Course, Compass Course with certain amount of Deviation given, True Course. Find the Variation from the chart and give its yearly change.
8. Give the Cross Bearings of two lights (any lights).
9. Plot a Two and Four Point Bearing, also Bearing Abeam. Boat heading on a certain course and speed known.
10. Show the use of the Protractor or Parallel Rulers.
11. Show how to plot the Current Course for allowance of Tide.
12. Show a method for finding position by Lead Line in a Fog.
13. Where do you find the Fog Signals of the different light houses and vessels?
14. Show the Day's Work, the Traverse Form, Change several Compass Courses to True Courses using the 360° circle and find their Difference of Latitude and Departure.
15. Show the Course and Distance Made Good.
16. Show the Latitude Left and the Latitude in.
17. Show the Difference of Longitude and the Longitude in; from the Longitude left.
18. Give the rules for finding the Latitude at Noon by the Meridian Altitude Method.
19. Pick out the Declination for day and time (any day or time).
20. Give description of methods you would use in a race or cruise down river and bay where Range Lights, Light Houses and Vessel may be met with.

21. Suppose you were in charge of a boat and found a man was steering off his course, you are short-handed and must let him "stick." Show method of checking his poor steering.
22. How would you determine your distance sailed in a fog?
23. Suppose you had a certain light ship to pick up in a race, some twenty miles on a certain course, and your compass or steering was out. Is there a way to take advantage of the wind?
24. Name the Range Lights of your Local Section.
25. Give the best safety harbors.
26. Where would you find the durations of the tides and their changes?
27. Is there any advantage in knowing the change of tide in a race of long distance on tidal waters?
28. Read off the Arc of the Sextant set to (any degrees, minutes and seconds of arc).
29. Show that you understand the Adjustments of your sextant.
30. Give method of finding the Index Error of your sextant, three ways.
31. Not having a Chronometer aboard, what would you do for correct time in a race or cruise of two days?
32. How do you secure Apparent Time? Equation of Time and Declination?
33. How do you take the Corrections for the number of hours after Greenwich for these times?
34. Give description of work for a long race, charts used, instruments used and books for reference.
35. Prove that you know how to find the True Bearing of the Sun from the Azimuth Tables.
36. Show the method of securing the Deviation by the Amplitudes and Tables 39-40 of Bowditch.

"COAST NAVIGATOR"

Questions—Rules of the Road must be understood thoroughly.

In connection with the questions for "Navigator," the following are demanded.

1. Can you secure Latitude by other means than the Meridian Altitude Method?
2. Why is the Latitude at sea considered accurate when taking the Meridian Altitude at Noon?
3. Give rules for taking sight for Latitude at Noon.
4. Having the Longitude, say at 8 A. M., how would you secure it at Noon?
5. Give the Time Sight method for Longitude.

6. Give the answer to the following. Chronometer has Accumulated Rate 6m. 4s. May 1st, at Noon slow of G. M. T. On June 10th, the Chronometer was compared with Time Ball while in harbor and found to be 7m. 24s. slow. What was the daily rate by June 10th, at Noon?
7. Had to work off shore for two days on account of weather conditions on board the "Gypsy." Yacht was knocked around by the high seas and felt sure the compass was in error. Give means to find the error.
8. Found compass was not giving Magnetic bearing or courses by range lights. Decided to swing motor boat after making harbor. Amount of Deviation was found to be excessive and seemingly, there was no cause for it. Give some statement about such matters.
9. Give ways to find compass error by calculation or tables.
10. Can you plot the Lines of Position by the Sumner Method? Give form.
11. Do you know the method of Position Lines by single Lat. and Long.? Explain form.
12. Having the Latitude at Noon by observation, when would you take a Time Sight for Longitude?
13. How do you know your sextant is correct at time of sight?
14. Suppose the Latitude by D. R. was out when you took the sight for Longitude, what would you expect in the problem when it was worked up?
15. Give method of finding position while off shore in a fog.
16. Caught in a hard blow and felt sure the boat would stand the racket, but decided it best to seek harbor. Wind North East and position of boat eighty miles E. N. E. of the North East End Light Vessel. What harbor would you try for, and give reasons?
17. Give the rules for storms.
18. Plot on the chart the following. Cross Bearings (locations to be chosen). Show by chart the position of the cruiser and distance to object on shore by the Two and Four Point Bearing rules.
19. Give information about crossing inlets in hard weather.
20. Show that you could find your position by stars.
21. Heading for a light on shore that is known and has a height of 160 ft. I see it come to the Horizon while standing on the cabin-top at a height above the sea 15 ft. Give the distance to the light.

22. From the chart, I find the Visibility of a certain light is 15½ miles at a height of 15 ft. from the surface of the sea. I find that the same light has a height from the Light List at 180 ft. at high water. Anxious to pick up the light, I climb to the spreaders of the sloop at a height of 30 ft., and find the light on the Horizon. Figured the tide is at top of flood. Want to know the distance to the light?
23. Heading for a light vessel and feel sure I am on my course to knock her bowsprit off. Pick a light up dead ahead, but the light is a flashing light instead of a fixed one. What is the trouble?
24. Have a Current running N. E. with drift of 2 miles per hour and wish to reach port which is 80 miles True North. Speed of cruiser is 8 knots per hour. Give the course to steer to make the best of Current, and give the speed per hour of cruiser.
25. Left Absecon Inlet Light Vessel heading N. E. True, Current running S. W. 1 mile per hour. Sailed with a free-wind at estimated speed of 7 knots for 12 hours. Give the Course and Distance Made Good.
26. Same problem as above, No. 25. What Course should I steer to make the best of the Current to reach Fire Island Light Vessel?

"OFF-SHORE NAVIGATOR"

Questions—The following list of questions is to be added to those for other Titles.

1. Can you set up a Runner and Tackle to keep mast in place? Give description.
2. Could you use sails to advantage on a power-driven boat? Give examples.
3. Is a sea-anchor of value at sea or in off-shore races?
4. Make the following knots. Short-splice, Long-splice, Bowline, Reef-knot, Two half hitches, Sheeps-hank, Diamond-knot.
5. Give some positions of boat in hard sea that will give her more chance.
6. What is required when sea gets up and is breaking over port or starboard side in such a manner to cause damage?
7. Give some safety plans for crew when off shore in races or cruises.
8. Show your knowledge of Logarithms.
9. Give directions for adjustment of the compass.
10. Work three examples for Latitude and Longitude by Sun, star and planet.
11. Give the rules for Single Altitude and Time for the Latitude.

12. Work two St. Hilaire problems by the Log. Have. Nat. Hav. method and set them on chart.
13. Give Daily Rate and Accumulated Rate of the chronometer.
14. Give Latitude by the Pole Star.
15. Form a Deviation table from time and compass bearings given.
16. Plot lines of position from the following data.
17. At sea and you wish to know what stars will be East and West of the Meridian at a certain Mean Time. Give the rules.
18. Give the rules for possible visibility of stars.
19. Show that you know the Meridian Passage of a heavenly body may or may not be its highest Alt.
20. Would you be at a loss to secure the Altitude of the Sun by a shore horizon?
21. Give rules for Identification of stars.
22. Show that you know a method for securing the correction of the chronometer.
23. Plot on chart Current Set and Drift and give Courses to steer to make the best of Current.
24. Show several ways to secure Departure and Distance from a light.
25. Give the laws of storms.

ANSWERS TO THE YACHTSMEN'S EXAMINATIONS FOR TITLES

"CREW"

1. Right, left sides, Starboard Right side, Port Left side.
2. Sailing Lights. Description under Lights required by the Government.
3. Enough to hold properly and to make allowance for rise of tide.
4. Watches named in the book.
5. Consult the Compass Card. 4 Cardinal and 4 Inter Cardinal Points.
6. 8 A. M. from signal at club house.
7. Down all bunting. Night pennant goes up. Commodore keeps pennant flying.
8. All halliards, sheets, must be coiled. Decks cleaned, covers on sails, ship put to order.
9. To prevent accident to the paint. Take them aboard when getting underway.
10. Steady, Drop the anchor, Check the run of a line, Allowing of the peak halliard to run. Never let it go from your hands, but keep it ready to check on orders. Ready to lower or raise the boom. All work finished.

11. If you are, better not go aboard. Five o'clock fine time to wash down. Use plenty of water and broom or swab. Gasoline takes off grease from paint. Sandsoap whitens hull.

12. Make yourself acquainted with the fire extinguishers aboard ship and see that the life preservers are aboard for every person before you take passage.

13. A good "Crew" must know how to row a boat.

14. You are not fit to be one of the crew of any boat if not able to swim.

15. This question will give you prestige with the examiner if you have had experience.

1. If four Lubber Lines, swing the boat until the second line comes on eight point from the first and note if the first line is on the other quadrant. Try all lines.

2. If compass is set on port of centre-line or keel-line. Run off line fore and aft at centre of boat. Run another line from Lubber Lines of Compass as far as possible fore and aft. Measure for centering of compass from line to line. Lines must be parallel.

   If compass is in line with keel, take long piece of timber-like clothes-prop, fasten at right angles a piece of lathe on each end, get centre of clothes-prop and place exactly in line with keel. Note the bearing of the two uprights at end of prop and see that they bear exactly the same number of degrees on each side of the Lubber Line of the compass.

3. Light should not be too bright. Wires should be twisted. Switch should be handy.

4. Heeling of the boat gives error to compass several degrees. This must be checked if on a long run in a sailing or motor yacht.

5. By the Azimuth Tables, By bearing of Range Lights, By Amplitudes and Table 39 Bowditch.

6. It does. Deviation found by the above methods are for the heading of the ship at time of taking the True Bearing of the Sun from the Tables.

7. Vibration of the engine, dry card compass, magnetic influence.

8. "Steer N.N.E.," he might order. Your answer—"N.N.E., Sir."

9. No Safety first Any change that takes the boat off her course for a length of time must be reported to the Navigator.

11. No. Check up now and then by the range.

12. Best to stick to the compass course, although you may take a look astern now and then.

13. Yes. During night, obstructions like buoys, may be seen better by switching off the light. Switch her on again every few minutes. You might be mistaken in the range.
14. Let her swing from side to side of the given course, but be sure she does not go to the Port side more than she does to the Starboard of the reverse. This will throw you off your desired course.
15. Have the boat on her given course when you are relieved from the wheel and sing out the given course to the fellow who relieves you, and make him repeat it before turning over the steering.
16. Names given on Compass Card in this book.
17. Into four equal parts called "Quarter Points."
18. Compass Card shows quarter points for Boxing the Compass.
19. Given on the Compass Card.
20. Consult Change of Courses in the book.
21. By the Azimuth Table and heading of the boat on the eight principal points of the compass you would have the Deviation from the problems for each course steered. Consult the Azimuth rules.
22. By the bearing of a know set of Range Lights.
23. Local Attraction, laying close to mass of iron ore, several boats close together.
24. This requires practice and a good steering outfit. Many men can steer as close as a degree. In off-shore work, you can be satisfied with nearly half a point off, on either side, but be sure they equalize each other.
25. Yes. Let her have her head to a certain extent so that the rudder will not stop speed of boat. Don't grind the wheel from side to side. Give the boat a chance and watch her take the sea. Do not favor one side of the course given. Show the Navigator what you are doing; he might give a new course or make allowances.
26. Variation is caused by the Magnetism of the earth and is equal for all points of the compass. It changes in every location.
27. From the Variation charts or from the sailing charts.
28. Some boats have a very large amount of kick, especially sailing craft. It is more noticed when crossing a bar.
29. Make yourself acquainted with the steering-gear of the boat you are going to steer.

30. Steering wheels should be large. Drums should be of the Wilcox Crittenden type. These drums are split and allow of tightening of the lines instantly. Quadrants should be used in place of the tillers under decks. Auxiliary tillers should be carried. Lines should be just thick enough to fall in the sheaves and quadrant nicely. Flexible bronze is used mostly. Sash cord is too stretchy. Turnbuckles should have stops so that they will not untwist. Rudder-heads should be large and have stuffing boxes to prevent water from coming over the ports into the boat. The rudder blade should be large enough but not too large. A small amount of balance is preferred. Too small a drum makes many turns of the steering wheel to get a boat on a course or to turn quickly.
31. I would request that the reverse bar be taken out of the boat for the race. The lever would go also. The engine may be worked from below. The iron would cause considerable Deviation of the compass.
32. Range Lights known. Follow them to port. Be sure you do not get mixed. Better find their distinctive flashes from the Light book.
33. Heavy squall coming from the North West. You are going up river and feel sure you can make the next turn by the time the storm is over or cleared enough to see ahead. Take compass bearing of the point ahead, look for any steamers coming your way, look at the chart for location of buoys, make allowance for the strength of the wind when she hits you and steer accordingly. If storm is not over or cleared by time you have calculated you should reach next turning point, plot course on chart and let her rip. Keep a good look out at all times, run slowly, watch for shoal water.
34. On long runs, a star will give direction for some time and may be sighted over the rail or part of the boat. Clouds give a short rest, steamer in sight, helps.

"LOCAL NAVIGATOR"

1. Consult book.
2. Make selection.
3. From the Light List published by the Government.
4. From this same book. Some charts give the Visibility.
   Remember the distance is calculated from a height of 15 feet from the water.
5. Found in the book.
6. To be selected.
7. To be selected by the examiner.

8. Lights to be selected and position adopted.
9. Rules in book.
10. Required to make demonstration.
11. Cuts and description in book.
12. Description in book.
13. In the Light List published by the Government.
14. Yachtsmen are required to do the Day's Work, correct courses to True Courses for Traverse Table. Difference of Lat. and Dep. taken from the Bowditch Table No. 2.
15. After the Diff. Lat. and Dep. have been deducted, the Diff. Lat. and Dep. is found in Table 2 of Bowditch and where coming together, the Course and Distance will be found.
16. Apply the Diff. Lat. to the Lat. left for the Lat. in.
17. The Dep. is found in the Lat. Column after the Middle Lat. is found as a Course. This will give the Diff. of Long. in the Distance Column.
    Apply this Diff. Long. to the Long. left to secure the Long. In.
18. Find the G.D. Take out the Declination for the day and correct it for the number of hours after noon at G. The G.D. shows this. Get the Obs. Alt. and correct it to the True Alt. Subtract the True Alt. from 90° and call it Z.D. and name it opposite name from the bearing of the Sun at time of sight. Add the Corrected Declination if of same name as the Z.D., but subtract one from the other, if of different names.
    The Equation of Time must be secured and corrected to have the Apparent Time for taking the Noon Sight or the time the Sun's centre is on the Meridian.
19. Use the Government Nautical Almanac and take the change in hours as given.
20. I would have charts of the waters sailed. Compass would be adjusted or the Deviation known. I would have Light List to check up flashes and Visibility. Would have courses laid out on chart. Would watch the steering carefully. Would run lights or ranges if there were the slightest chance of going out of the direction or had a bunch of poor steersmen aboard. Would know the change of tides and their velocity in certain locations of the run. Would try to favor the boat by shortest distance to points if it did not interfere with good steering. Compass steering is not always good practice with new men aboard; so would give them some point to steer by. The range lights would answer this question.

21. Would make allowance for left or right handed man when steering. Would watch his wheel-play and allow for course by giving him another course to check his poor steering.
22. By the Taff Rail Log. By the revolutions of the engine and the known speed per hour. Weather conditions would govern me in regards to allowing for the time sailed from a point to another point.
23. In a fog and wind going, I would try my best to pick up the light-ship to leeward. This would allow me to hear her Fog Signal.
24. To be selected.
25. Harbors of locations to be selected.
26. In the Tide Tables gotten out by the Government.
27. Yes. The tides change on different sides of river and bay some half hour ahead of each other and may be taken advantage of, if it does not require going out of the course too far, to make the change desirable.
28. Sextant to be set by Examiner.
29. Adjustments of the Sextant found in the book.
30. By the Star. Bringing the reflected image to cover the star. Amount of error is shown on the arc of the sextant. By the Sea Horizon. Bring the reflected and Horizon in line and then consult the Arc for the error. By the Semidiameter of the Sun. Bring the upper limb of the reflected Sun to the lower limb of the Sun and note the error, on or off the arc. Change the positions of the two suns and note again, and subtract the errors secured; now divide the error by 2 and the remainder is the error, on or off the arc. If on the arc, it is marked minus. If off the arc, it is marked plus.
31. Call up a firm like John E. Hands & Sons Co., 224 Walnut street, Philadelphia, and ask for the time. Set the watch to that time and try again, and then note the difference. This will be good enough for calculating rough Longitude, Apparent Time, for two days.
32. Rules given in this book.
33. From the Nautical Almanac. Longitude and time at place is also noted to give the required number of hours, minutes and seconds afternoon at Greenwich.
34. Long-distance racing at sea requires all the valuable instruments in navigation just as much as a ship sailing to a foreign port. Chronometer must be on board to give the Greenwich Time. Sextant must be on hand. Table for Azimuth, rules for working problems, compasses and lead-line. Taff-rail logs, sea-anchor and

Nautical Almanacs. Log-book, charts, Protractor, Sumner charts, blank compass, Bowditch Tables, plenty of blank books or paper.

35. I would know the Apparent Time I took the True Bearing of the Sun or star. I would know the Corrected Declination at time of bearing. I would know the Latitude. Taking out the True Bearing of the body, I would apply the Variation of the location I was in, and then the Compass Azimuth to the Magnetic Azimuth for the Deviation. I would apply the names of Deviation in accordance as the Magnetic Azimuth was to the right or left of the Compass Azimuth.

36. Rules given with examples.

A plan adopted by the author when going off shore or in races at night of long-distance, is to run life-lines around the stanchions. This has saved many a man from going over the side. Life preservers and rings are placed in several parts of the boat for immediate service. One ring is fitted with long line and hung at stern by slip-knot cord for service in case of man overboard. Life boats have always been kept clear of duffel and fully equipped for service.

Two men have always been on deck at all times so that no accident could happen to one man without its knowledge at once from the other.

Engine rooms have been fitted with rails to prevent accident to men and to engine or electrical equipments.

In sail boats, the running of line is not permissible, but life preservers may be placed, men kept off their feet, sails reefed before darkness, all lights placed before hard weather starts, men made fast to line in case of fore-work or taking-in racing sails. Fire drills have been given before sailing a long-distance race and places of the extinguishers known by all hands. No smoking below decks.

These suggestions and others should be adopted by those who qualify as Navigators.

"COAST NAVIGATOR"

1. Yes, by the Single Altitude and Time problem for Stars or Sun, also Ex. Meridian sights before or after Noon. Examples in book.
2. The Sun has reached its highest Altitude. Refraction is less than at other times and the Sun has little motion, seemingly, at that time.

3. I prefer to know the L.A.T. for the sight and take the Altitude at that time instead of waiting for the Sun to "dip" as it is called or drop towards the Westward. The rules for taking the sight and working the problems are in book.
4. As the Chronometer shows G.M.T. and my watch shows L.M.T. I would know the Longitude at Noon. This is not exact, however. The position at 8 A. M. may be worked up to Noon by D.R. The Latitude at Noon may be used over again with the Longitude problem of the A.M. sight to secure more accurate Longitude at 8 A. M. and then worked up to Noon for the Run on the course till Noon. The St. Hilaire Method may be used during the run to Noon and Lines of Position plotted or figured to secure the Longitude near Noon.
5. Longitude secured by the Chronometer is called the "Time Sight." The instant of contact of the Sun's limb with the Horizon is noted by stop-watch, the Altitude read from the Sextant and the problem worked with the Lat. by D.R. The problem gives the Local Apparent Time at Ship or place, and the Chronometer Times gives G.A.T. after Eq. T. is applied. One subtracted from the other give the Longitude after the time is changed into Arc.
6. Slow May 1st at Noon 6m.4s. Slow June 10th at Noon, 7m.24s. Loss since May 1st at Noon to June 10th at Noon, 1m.20s. Days elapsed, 40. Daily rate, 2s. losing.
7. Storm over and Sun showing so took several Azimuths of the Sun on different headings and found Deviation considerable. Must have been caused by the hard battering of the seas. Used Sunrise and Sunset for Amplitudes before reaching port and found the Azimuths agreed with the Amplitude problems for Deviation.
8. Swung the motor boat on eight headings and found considerable Deviation. This should not have been as the compass was adjusted before going on the cruise by an expert. Was at a loss to account for the Deviation. Later, found that one of the boys had dropped a large oyster knife in the Binnacle. Its withdrawal settled the trouble.
9. The Azimuth tables give the True Bearing of the Sun or Stars, the Bowditch gives the True Bearing of the Sun at Sunrise and Sunset. With these two tables the Deviation may be found. The Altitude Azimuth and the Calculation for Amplitudes are also used to secure Deviation. Problems in book.
10. Lines of Position may be plotted on charts after the Lat. and Long. is found. The Azimuth of the Sun at time of sight is secured from Azimuth tables and set down to the dot placed on the chart, at the position given by the Lat. and Long. and a line at right angles is drawn across the dot and the Azimuth line.

This is the Position Line. Another Azimuth is set down after sailing two hours and the Second Line of Position is made from the new sight for either Lat. or Long. The crossing of the lines shows the location of the boat at time of the second sight.

11. The Sumner lines may be set down by securing the Azimuth at time of sight. This does away with working two Long. problems for the lines. Method explained in book.
12. I would consult the Azimuth tables to find out the position of the Sun and take sight when the Sun was nearest the Prime Vertical or bearing as near West as possible. This would give me a more correct Long. than taking the sight before. The amount of the D.R. being out for the Lat. makes less difference at this time when securing the sight of Long. This Alt. must not be too low, however.
13. It has been a rule with me to look over the adjustments of the sextant every time I take a sight as someone might unintentionally set one of the screws out a little. The adjustments for the sextant given in the book.
14. If the Lat. was out, I would expect my Long. sight to be off, if I had not taken the sight near the Prime Vertical. The Sumner lines would show me the amount of Lat. out of the way and I could work with an assumed Lat. after plotting the supposed position.
15. If on soundings, the lead-line, course run, time of each run and sounding noted, would give a line of sounding and from them, after finding same on the chart, I could plot my position and know direction for port. Example in book.
16. If boat ran before storm better than heading into it, I would let her go for Cold Spring Inlet or the Breakwater, off the Delaware Capes. The chances are that I could make Cold Spring Inlet, as the place is well marked at night with two large piers running to sea for a mile. If the sea was too heavy when reaching there, I still would have a chance to run across the Delaware Bay to the Harbor of Refuge or Breakwater.
17. Refer to Bowditch. Too long a subject to take up in this small book.
18. Problems given in the book.
19. Only in day time would I tackle a new inlet in hard weather, and then I would have the lead-line going even should I see all the buoys. There is so much change during the season on the coast at these inlets, it is better to watch

the water for depth and keep the lead going instead of trusting entirely to the buoys that mark the channel. If range lights are placed, it would be safe to tackle an inlet at night. Boat must be properly closed and all stuff taken from the decks before going over inlets. All movable articles below decks, should be properly placed in lockers, so that nothing may get to the engine or be destroyed. Steering should be done by one who has been there before and he must have full charge at the time of crossing. Better to give the boat her head when a heavy, breaking, sea comes under the stern, but don't let her broach-to, or there will be a mixup. Small boats towing astern must have plenty of line if it is not possible to get her on deck. Life-ring and long line attached, should be handy in case of man going over the side. It is possible to get a man, even in hard seas with a motor boat, if you have the skill to handle the boat. The life-line should be let down to him, if boat is near the break, but control of engine must be had at all times.

20. Lat. and Long. may be secured by the stars. The North Star may be worked for Lat. Position of the North Star, so high in the heavens, gives a goodly slant for position at all times when the weather is clear in N. Latitude.
21. Table 6 of Bowditch gives visibility for 160 ft. 14.5 Nautical Miles.
For 15 ft. 4.4 miles. Added, gives the Distance to the light. Ans. 18.91 or 19 miles.
22. Visibility for 180 ft. is 15.4 miles. For 30 ft. is 6.3 miles. Added, gives the distance to the light.
23. As the light seems to be flashing instead of fixed, the run of the sea puts the light out when the cruiser drops down from the top of the seas. When she reaches the top of the sea, the light is seen again, making it appear to be flashing. Climb the rigging and prove the light is a Fixed Light.
24. Angle between True N. and N.E. is 45° with this as Course and 20 miles as Dist. enter the Table No. 2 and find the Diff. Lat. and Dep. 14.1 and 14.1. With this Dep. and Dist. to Port 80 miles, find the Diff. Lat. and at top of page, the Course. They are Diff. Lat. 78.8 and Course 10°. Add this 10° to Course True N. for the sailing course to get the best out of the tide. The two Diff. Lats. show the rate of approach for 10 hours towards the Port, 64.7 miles. As the tide was against cruiser she would naturally be cut down in her speed. Gives her a speed of 6½ knots nearly.
25. Course 45° and Dist. 84 miles, and Course of Current 45° and Dist., or number of miles tide will run while sailing the course, is 12 miles. In the Table No. 2 we have the Diff. Lats. and Deps. When they are subtracted, we have Diff.

Lat. 50.9 N. and Dep. 50.9 E. When they are compared, in line across columns, in table, they give the Course and Distance Made Good. Ans. Course M.G. N.45°E. Distance M.G. 72 miles.

26. As the Current is dead ahead, it has effect of cutting down the speed of boat 1 mile every hour she sails in it. There could be no advantage taken of the current under the conditions other than steering directly into it.

"OFF-SHORE NAVIGATOR"

1. Runner has standing part of wire or Manilla with sister-hooks at one end or spliced-in eye, other end has single or double block. Tackle may be the luff tackle or of more parts. End block is made fast to eyebolt or part of craft aft. The runner is made fast to mast or spar and the tackle set up to take off strain or to place in position.
2. Sails may be used while at sea to steady the craft. It is doubtful if they give more speed to the boat. A properly designed sail and properly placed mast are all right to heaveto with, but the sail must be well aft. Sails might be able to get a boat to some port should the gas run out.
3. A sea anchor is useless on most of the motor craft without after-sail may be set. In most cases the boat goes off sidewise and will not lay to the sea anchor. If sail is aft, she will work all right. In race off shore, it is best to have a sea-anchor and proper sail well aft for hard weather.
4. Knowledge of the knots required.
5. Running with storm diminishes the force of the wind nearly fifty per cent. Boats head sea.

   Laying to is resorted to when the storm has made it impossible to continue voyage.
6. Better change the course and let go the oil bags.
7. Nets set in place completely around the boat at a height of six feet. Lines run from the awning stanchions not less than three running lines and lines made fast with marlin to the stanchions. Always do it when in off-shore work. Life preservers ready, life ring and long line at hand, fire extinguishers in place and the crew well acquainted with their makeup and use, rails around engine and hand rails placed in dangerous places.
8. Reference is made to Bowditch for Logarithms. Tables given in this book.
9. Adjustment of compasses is a life-long study. For the yachtsmen the answer may be given for the Azimuth and Amplitude methods of securing Deviation. Yachtsmen should have some knowledge of placing magnets to conteract magnetic influence. See book.

10. Examples given in this book.
11. Rules given in this book.
12. Yachtsmen are required to know this problem as it gives them a method to secure their position at practically any time. Examples and methods given in this book.
13. Examples in this book.
14. See example in this book.
15. Several Forms in this book.
16. Example is to be given and the Lines of Position to be set down. Examples in this book.
17. I would turn my L.M.T. into L.S.T. and then hunt up the R.A. of the stars from the N.A. and subtract L.S.T. and R.A. one from the other, to find out if the star is East or West of my Meridian. If the L.S.T. is best, the star is West, and if least, the star is East.
18. If star's declination has different name from the Latitude of place and the star's Declination greater than the Co-Lat. (Lat. sub. from 90°), the star is not seen in that Latitude. If the star's Declination and the Latitude of place have same names and the Co-Lat. is less than the Declination of the star, the star is never below the Horizon. They are called Circumpolar Stars.
19. If the observer's position is changing rapidly in Latitude, then the greatest Altitude of a heavenly body may not be the Meridian Altitude.
20. Table given with example in this book.
21. See rules and examples in this book.
22. Method shown in this book.
23. Examples and drawings in this book.
24. Drawings and examples given in this book.
25. Refer to Bowditch.

GET THE TOOLS, MEN

This book is to boost off-shore cruising and racing by helping with the problems of navigation, but you cannot hope to work problems from the book or do the work of a navigator without tools.

The requirements for working the problems are as follows: Bowditch Tables, secured from the Government at Washington, D. C., or from nautical store; Almanacs of the years that the problems are based on, gotten from the Government; Azimuth Tables, red-bound volume, from Government.

If you wish to tackle the sights similar to those given in the book, you will require Sextant, CORRECT TIME and Artificial Horizon. With these articles you may go to your third-story window or roof and do sight work just as well as at sea.

The Artificial Horizon that I use is nothing but a 6x7 developing tray (black), heavy oil and a wind shield made of the thinnest celluloid to keep the wind from blowing the oil all over the ditch. Make two sides lengthwise, with angle of 45°; nail two little strips of wood crosswise to the sidepieces and make them lower than the height of your tray, then cover with the thin celluloid. This may be gotten from a large firm in photo supplies. It is used for covering a wet negative to get a very quick print. It is so thin there seems to be very little refraction. If glass is used, as they cover the bought Artificial Horizon, it must have parallel sides and, even at that, you are apt to get a bum contact and make the reading of your Sextant larger than it should be.

Don't forget to take off or add the Index Error of your instrument to the Observed Altitude before you divided it by 2. There is no DIP when using the Art. Hor. All Obs. Alts. MUST be divided by 2 when using the Art. Hor.

CORRECT TIME—Call up your nautical instrument firm or local telegraph office and get the correct time before tackling your sights. If you have a stop watch, take a look at the time, wait until your second hand comes to the start of the next minute and then let go the stop-hand. Go to the phone and get the time.

If your firm handles Chronometers, they will call something like this: "Coming on 35," meaning—you know the hour and the supposed minutes and seconds, and they are ready to tell you when the correct time is 35 minutes after a certain hour. Then they will sing out, "Stand by," and you are watching your second hand or ready to stop the stop-hand. Then they will call, "Time," and you have 35 minutes after the hour. Now stick down what they gave you and subtract or add what your time is for correction of your watch.

TAKING THE SIGHT

On the roof with correct time, oil tray and sextant, all ready for a sight at NOON for Latitude. If you are wise, you will look up the Nautical Almanac for your Equation of Time for the day, and correct it for the number of hours past Greenwich Noon, and then apply it to your watch time. Remember that the Equation of Time is some days as much as 12 minutes before your NOON and other days astern of NOON. The sights must be taken at Apparent Times, meaning the Equation of Time applied to your watch time gives the time to take the sights.

Place the Artificial Horizon out of the wind if possible and squint at the oil to see the Sun's reflection or the Star, Moon or Planet. Get the sextant up to your eye and bring down the Lower Limb of the Sun to contact with the Upper Limb of the reflected Sun, and measure the angle on the Arc of your sextant. If a Star is taken for Altitude, bring the star down until it covers the reflected star.

Say, it is NOON, Apparent Time. You have brought the two Suns together at that time by watch and have the reading from the sextant of 60° 20′ 30″. You must now apply the Index Error of your instrument, get the Refraction and Parallax from Bowditch Table 20B subtracted from Alt. Hunt up the Semidiameter from the Almanac and Add it to Alt. No Dip. This gives you the True Altitude to be used in securing the Latitude.

Don't forget to apply the Index Error of your instrument before dividing the Observed Altitude by 2. If at sea, you would have to apply the Dip from Bowditch Table 14 subtractive. Get out the Declination for the day and correct it for the number of hours after Noon at Greenwich from the Nautical Almanac. If your Latitude and Declination are of like names, you add; if different named, subtract for Latitude.

The Longitude problem is worked the same way for True Altitude, but you use the watch to get the correct time of sight, which must be changed to Greenwich Apparent Time by adding the Longitude you are in to watch time if Long. is West, and subtracting if East. Be sure to change this.

Time at Greenwich to Greenwich Apparent Time by applying the Equation of Time, as marked in the Nautical Almanac, with correction for the number of hours past NOON at Greenwich. Remember that Local Time and Longitude of Local Place, if west, are added to give Greenwich Mean Time.

With your True Altitude and time you use the formula for working the Time Sight for Long.

BUOYS

Name the buoys and give the side they are to be passed when entering from the sea.

Red Buoys with even numbers will be found on the Starboard side.

Black Buoys with odd numbers will be found on the Port side.

Buoys painted with black and red horizontal stripes will be found on obstructions and may be left on either hand.

Buoys painted with black and white perpendicular stripes will be found in mid-channel, and must be passed close by to avoid danger.

All other distinguishing marks on buoys are in addition to those mentioned. They are employed to mark particular spots.

Perches with balls, cages, etc., when placed on buoys indicate turning points, their color and number indicating on what side it must be passed.

Nun Buoys, properly colored and numbered, are usually placed on the Starboard Side, and Can Buoys on the Port side of channels.

Nun Buoys are conical in shape.

Can Buoys are cylindrical in shape.

All Spar Buoys are Spar shaped.

A Bell Buoy has a flat deck, nearly awash, with superstructure supporting a bell.

A Whistling Buoy is conical in shape, with whistle at top.

Lighted Buoys have cylindrical or conical bodies, containing gas, surmounted by a superstructure with Lantern. Combination Buoys have bell or whistle, as case may be.

Whistling and bell buoys are sounded only by the action of the sea; therefore, in calm weather, they are less effective or may not be heard.

Light vessels en route to or from station, or off station, will fly the International Code signal letters "QE" (signifying "light ship is not at anchor on her station").

All light vessels on light-vessel stations and all vessels relieving station ship will display the International Code signal of the station whenever a vessel is approaching or in the vicinity, and when there are indications that such vessel is in strange waters or fails to recognize the station, or when the vessel asks for the information.

Caution regarding buoys.—Buoys are liable to be carried away, shifted, capsized, sunk, etc., lighted buoys may be extinguished, or whistling or bell buoys may not sound, as the result of storm, the accumulation of ice, running ice or other natural causes, or collision, or other accidents.

WHAT ARE THE WHISTLE SIGNALS?

Steam Vessel means any vessel propelled by machinery.

Underway means not at anchor, or made fast to the shore, or aground.

There is risk of collision when the compass bearing of two approaching vessels does not change.

The whistle signals in these rules must be sounded on an efficient whistle or siren.

Vessels on the high seas and on the coasts of the United States, and on the waters emptying therein, give their signals when in *Sight* of each other.

Vessels on the Great Lakes and their tributary waters sound their signals when they are within *half* mile of each other.

Cross signals, that is, answering one whistle with two, or two whistles with one, are prohibited. When two vessels are approaching each other, and either vessel fails to understand the course or intention of the other, the vessel in doubt must immediately signify the same by giving several short and rapid blasts, not less than four, the *danger signal.*

Unnecessary blowing of the whistle is prohibited.

A short blast means a blast of about one second's duration.

A prolonged blast means a blast of from four to six seconds' duration.

SIGNALS FOR OCEAN VESSELS

One short means I am directing my course to Starboard (right).

Two short means I am directing my course to Port (left).

Three short means my engines are working full speed astern.

Several short and rapid blasts, danger signal.

A steamer in a fog, and when leaving a dock, and when approaching a bend in a river, gives one long blast of the whistle.

One long followed by two short blasts, *towing* steamer in a fog.

A vessel being towed in a fog may blow the same signal, but no other.

Continuous blowing of the whistle means "distress."

Rapid ringing of a bell from three to five seconds means anchored in a fog or aground in a fairway.

Sailing Vessels under way in a fog must sound the following signals on an efficient fog horn. The same signals apply to sailing vessels on the Great Lakes:

On the Starboard tack, one blast.

On the Port tack, two blasts in succession.

Wind abaft the beam, three blasts in succession.

Vessels 20 tons or upwards fishing. Blow one blast of the whistle and follow it by ringing a bell.

WHAT ARE THE BELL SIGNALS?
Starting, Stopping and Backing Signals From the Bridge to the Engine Room on Ocean and Coastwise Vessels

One bell.....Ahead slow
Jingle bell.....Full speed
One bell.....Slow
One bell when going *slow ahead* means.....Stop
Two bells when stopped means.....Slow astern
Jingle when going astern slow means.....Full speed astern
One bell when going full speed astern means.....Slow astern
One bell when going slow astern means.....Stop
Four bells and a jingle means from full speed ahead to full speed astern.
Three bells and a jingle means from full speed astern to full speed ahead.

Where can we find information about the lights of our rivers?

From the Department of Commerce Light House Service.

Give description of the system of lighting rivers.

FROM THE BUOY LIST LIGHTS

Illuminating apparatus consists of a source of light placed in an optical apparatus. Usually, for the purpose of concentrating the light and directing it toward the horizon or in horizontal beams to sweep the horizon, there is an arrangement of lenses, prisms and reflectors in various combinations. The lenses act as refractors of the light, and the prisms may act as refractors or reflectors, or both. The system of reflectors is named catoptric, of refractors dioptric, and the combination of the two catadioptric.

To vary the characteristics of lights, there are flashing and occulting mechanisms, by which lens panels or screens are revolved, or the light periodically obscured by

shutters, or in the case of gas or electric lights the supply of gas or current is cut off. Lights are also distinguished by the number of lights or by showing either a fixed color over definite areas or a colored flash, this being effected by the use of colored glass. The source of light for the greater number of lights is a special form of kerosene-oil wick lamp, but in recent years other more powerful lamps and illuminants have been introduced. The oil-vapor lamp, burning vaporized kerosene oil under an incandescent mantle, gives a much more powerful light. Oil gas is extensively used, particularly for lighted buoys; acetylene gas is used for lighted buoys and unattended lighted beacons. Electric arc lights, electric incandescent lights and coal-gas lights are used in special instances.

Bearings are given in this List in *degrees true*, reading clockwise from 0° at N. to 360°; bearings relating to visibility of lights are given as observed from a vessel.

Distances are given in *nautical* miles, unless otherwise stated.

Heights are referred to *mean high water*.

Depths are referred to *mean low water*.

Unwatched lights.—"U" after the name of a light indicates that the light is unwatched. In addition, all gas buoys are unwatched. Gas buoys cannot be implicitly relied upon, as they may become extinguished, or if intermittent, the apparatus may get out of order, and some time may elapse before they can be reached to repair or relight. The same is true in a less degree of unwatched lights on fixed structures.

Too much reliance must not be placed on lighted buoys maintaining their exact positions; it is safer, when possible, to navigate by bearings or angles to fixed objects on shore, and by the use of soundings.

Character of lights.—In order to avoid the likelihood of confusion between lights, endeavor is made to give the lights distinct characteristics.

The characteristics of the lights are indicated in the List by abbreviations, as follows:

(1) Lights which do not change color.	Characteristic phases.	(2) Lights which do change color (showing alternately white and red in various combinations).
F.=Fixed	A continuous steady light.....	**Alt.**=Alternating.
Fl.=Flashing	(a) Showing a single flash at regular intervals ..... (b) A steady light with total eclipses.	**Alt. Fl.** = Alternating flashing.
F. Fl.=Fixed and Flashing	A fixed light varied at regular intervals by one or more flashes, usually of greater brilliancy. A flash is preceded and followed by a diminution of light or an eclipse.	**Alt. F. Fl.**=Alternating fixed and flashing.
Gp. Fl.=Group flashing.....	Showing at regular intervals groups of flashes	**Alt. Gp. Fl.**=Alternating group flashing.
Occ.=Occulting.	A steady light suddenly and totally eclipsed at regular intervals.	**Alt. Occ.**=Alternating occulting.
Gp. Occ.=Group occulting..	A steady light suddenly and totally eclipsed by a group of two or more eclipses.	

A flash is always shorter than the duration of an eclipse.

An occultation is shorter than or equal to the duration of light.

Lights are characterized as flashing or occulting solely according to the relative durations of light and darkness and without reference to the type of illuminating apparatus employed or relative brilliancy.

In approaching a light of varying intensity, such as fixed varied by flashes, or alternating white and red, due allowance must be made for the inferior brightness of the less powerful part of the light. The first-named light may, on account of distance or haze, show flashes only, and the true characteristic will not be observed until the observer comes within the range of the fixed light; similarly the second named may show as occulting white until the observer comes within the range of the red light. Also where there are two fixed lights, one white and one red, the latter may be obscured and the station may appear to show only a fixed white light.

At short distances and in clear weather flashing lights may show a faint continuous light.

Period of a flashing or occulting light is the time required to go through the full set of changes in the light. This total time is given in the column "Name, etc.—Character and period of light"; and the details are stated in the column "Remarks—Fog signal."

The durations of light and darkness given are those for which the apparatus is designed, and may vary slightly with irregularities in the working of the apparatus or because the apparent duration of a flash may be reduced by great distance or haze.

A light in which the flash or occultation is caused by revolving lenses or screens may apparently differ from the given period when observed at short distances from a rapidly moving vessel nearly abeam, the period and duration being increased or diminished according as the vessel is moving with or against the direction of revolution of the apparatus.

Visibility of lights.—The distances given in the Buoy List at which lights of sufficient power may be seen in clear weather are computed in nautical miles for a height of the observer's eye of 15 feet above the water level. These distances may at times be increased by abnormal atmospheric refraction, and, of course, may be greatly lessened by unfavorable weather conditions, due to fog, rain, haze or smoke. Weak lights and colored lights are easily obscured by such conditions.

CLOUDS

Name the forms of clouds with regard to their altitude above the earth.

Answer:
1. CIRRUS (Ci.). Detached clouds, feathery like, of white color.
2. CIRRO-STRATUS (Ci.-S.). A thin whitish sheet covering the sky.
3. CIRRO-CUMULUS (Ci.-Cu.). Small globular masses arranged in groups.
4. ALTO-CUMULUS (A.-Cu.). Rather large globular masses, white or grayish.
5. ALTO-STRATUS (A.-S.). A thick sheet of gray or bluish color.
6. STRATO-CUMULUS (S.-Cu.). Large globular masses or rolls of dark clouds.
7. NIMBUS (N.). Rain clouds with ragged edges.
8. CUMULUS (Cu.). Wool-packed clouds with upper surfaces dome-shaped.
9. CUMULO-NIMBUS (Cu.-N.). Thunder clouds or rain clouds. Form like mountains.
10. STRATUS (S.). Horizontal sheet of lifted fog.

PUBLICATIONS BY THE GOVERNMENT

Name some publications that the Government gives to mariners, and give description.

The following are secured from the Hydrographic Office in large cities:

PILOT CHARTS, give drift of ice, derelicts, floating obstructions, tracts of storms, condition of wind and weather, ocean currents, variation, etc.

HYDROGRAPHIC BULLETIN, published weekly, with more details of Pilot Charts, use of oil on sea.

NOTICE TO MARINERS, published weekly, with aids to navigation, dangers to navigation, new soundings, information about charts.

INSTRUMENTS FOR GIVING WEATHER CONDITIONS

Name some instruments for giving weather change. Ans. Mercurial Barometer and the Aneroid Barometer, the Thermometer.

Give description of each. Ans. The Mercurial Barometer indicates the pressure of the atmosphere by the height of a column of Mercury. The Aneroid Barometer measures the pressure of the air by an elastic plate of metal. All Barometers should be tested at different times by a Standard instrument, as they generally read too high or too low. The Thermometer indicates temperature.

The Thermometer may be used to test the temperature of water to show position of ship at sea. This is done when boats enter the Gulf Stream. A bucket is let over the side after it has been weighted so that it will sink about three feet below the surface. The water is taken on deck, and the Thermometer immersed to get the reading.

HOW TO USE THE ANEROID BAROMETER

Attention to the following brief practical observations will enable any one to use the Barometer successfully.

The Barometer should be placed where least exposed to accidents. Care should be taken to ascertain its being in perfect order; that it works freely, and stands correctly, by having it compared with a standard Barometer. It should have a Thermometer attached to show the temperature.

The divisions upon the scale of an Aneroid Barometer represent inches and fractions of an inch of atmospheric pressure; the usual range of scale on Aneroids for marine use is from 28 inches to 31 inches.

The words "stormy," "fair," "rain," &c., upon the dial are simply relative, as it does not follow that the weather conditions indicated by these words will necessarily exist when the indicating hand of the Barometer points to them. It is not so much the absolute height as the actual rising and falling of the Barometer which determines the kind of weather likely to follow, and on many of the better quality Aneroids for marine use these words are now omitted from the dial.

In forecasting the weather there are several conditions other than atmospheric pressure which must be taken into consideration—namely, the direction and force of the wind, the humidity of the air and, most important of all, a comparison of the daily Barometer reading with the indicated pressure of several days preceding. A single

observation of the Barometer, without reference to the conditions prevailing at definite intervals preceding, is liable to be misleading; the important thing to know is, has the rise or fall been a slow or gradual one or has it been rapid.

Observations should be made daily of the height of the Barometer—the temperature as shown by the attached Thermometer, also the direction of the wind (both of which affect the Instrument) and noted down.

A "rising" Barometer is when the hand is moving up, or toward the higher numbers on the scale; a "falling" Barometer, the reverse.

Generally the rising of the Barometer presages fair weather, and its falling, rain, snow or high winds. If the fall be rapid, the storm will be violent, but of short duration; if the fall be slow, it will be less violent, but of longer continuance. No great storm ever set in with a rising Barometer.

Great elevations in summer are attended with fine dry weather; great depressions with storms of wind and rain, with thunder and heat; cold, unseasonable weather usually succeeds these depressions.

Great elevations in winter, after a gale from the southwest, with rain, are usually followed with a clear sky, and sharp white frosts; great depressions being on a thaw.

A fall of the Barometer, with a south wind, is followed by rain, in greater or less quantities.

A fall of the Barometer, sudden and considerable, with the wind due west, indicates a violent storm from the north or northwest, during which the Barometer will rise to its former height.

A steady and considerable fall of the Barometer during an east wind denotes that the wind will go round to the south, unless a heavy fall of rain or snow immediately follow.

A falling Barometer, with the wind at north, brings the worst kind of weather; in summer, rain and gales follow; in spring, deep snows and frosts.

This is of rare occurrence.

If after a storm of wind and rain, the Barometer remains steady at the point to which it had fallen, severe weather may follow, without a change of the wind; but on the rising of the Barometer a change of wind may be expected.

The Barometer usually stands higher with easterly than it does with westerly winds; and with those from the polar regions higher than with those from the direction of the equator.

In the tropical regions the variations are not so great as north or south of them, and are greater in winter than in summer.

GENERAL BAROMETER INDICATIONS

A gradual but steady rise indicates settled fair weather.
A gradual but steady fall indicates unsettled or wet weather.
A rapid rise indicates clear weather with high winds.
A sudden fall indicates a sudden shower or high winds, or both.
A stationary Barometer indicates a continuance of existing conditions.

THE BOWDITCH TABLES

TABLE NO. 2 gives the Diff. Lat. and Dep. for courses, and the distance of the run.

What is the Diff. Lat. and Dep. for Course 60° and Distance run 40 miles? Ans. 20.0, 34.6.

TABLE NO. 3 gives the Meridional Parts.

Give Meridional Parts for 38° 47′. Ans. 2513.6. For 32° 21′. Ans. 2040.7.

TABLE NO. 4 gives Length of a Degree in Latitude and Longitude.

What is length of a degree of Longitude in Latitude 40°? Ans. 46.079 miles.

What is length of a degree of Longitude in Latitude 0? Ans. 60.068 miles. The Equator.

TABLE NO. 6 gives the Distance of Visibility of Objects at Sea.

What is the distance to an object, that has a height of 100 feet when viewed from sea at height of eye 12 feet? Ans. 26 nautical miles.

TABLE NO. 7 is used to change Arc into Time and the reverse.

What is the Time corresponding to 75°? Ans. 5 hours. Give Arc corresponding to 6 hours. Ans. 90°.

TABLES NOS. 8 and 9, changes in Sidereal and Mean Time.

What is the quantity to be subtracted from 17 hours Sidereal Time to get corresponding Mean Time? Ans. 2 m. 47.102 s. Give quantity to be added to Mean Time 16 hours to get Sidereal Time. Ans. 2 m. 37.70 s.

TABLE NO. 13 gives the change of Right Ascension for any number of hours. The Hourly variation as taken from the Nautical Almanac is given in the side column and the number of hours is taken from the top. The change is taken from down columns in line with the Hourly variation.

What is the change of Right Ascension for 6 hours with an Hourly variation of 9 seconds? Ans. 54 seconds.

TABLE NO. 14 gives the Dip of the Sea Horizon. It is used when correcting the Observed Altitude to get True Altitude. Always subtractive. Not used with Artificial Horizon.

What is the Dip for 15 feet? Ans. 3′ 48″ sub. For 38 feet? Ans. 6′ 02″ sub.

TABLE NO. 20A gives the Mean Refraction which is a minus quantity when getting the True Altitude from the Observed. You use this when taking sights with Artificial Horizon as there is no Parallax which is joined with Table No. 20B, for use without Art. Hor.

What is the Refraction for 32°? Ans. 1′ 33″. For 5°? Ans. 9′ 52″.

TABLE 20B gives the Refraction and Parallax that is subtracted from the Observed Altitude. It is also Minus.

What is the correction in Refraction and Parallax for Altitude 20°? Ans. 2′ 31″. For 10°? Ans. 5′ 10″. For 83°? Ans. 0′ 6″. For 90°? Ans. 0′ 0″.

TABLE NO. 26 gives the Variation of Altitude in one minute from Meridian Passage. This table is used when taking sight for Latitude several minutes before NOON or after that hour. It may be used up to 26 minutes before or after noon. You get the Declination for the time of sight and find it at top of page. Be sure it has the same name as the Latitude, or find the pages with different names. Now hunt down column until you find your supposed Latitude and across page, where the Latitude and Declination meet you will find the difference to be taken again in Table No. 27.

Try out Declination 10° N. and Latitude 40° N. Time from Noon 12 minutes. Ans. Lat. and Dec. same name, in side column will be found 3″. This is to be taken again in side column in Table No. 27, where you will find under Time from Noon or Meridian Passage, the full quantity, which is 7′ 12°, to be added to the Observed Altitude.

Give the difference from Tables Nos. 26 and 27 for Latitude 30° N. Declination 21° S. and Time from Noon 26 minutes. Ans. TABLE NO. 26 with Dec. and Lat. of different names gives 2″. This in TABLE NO. 27 side column and across until the Time from Noon is found at top, gives 22′ 32′.

TABLE NO. 29 gives change of Nautical Mile into Statute Mile and the reverse. The Nautical Mile, or Knot, equals 6,080 feet and the Statute Mile equals 5,280 feet. This table is self-explanatory.

TABLE NO. 35 gives the speed per hour that a boat sails over a measured mile in so many minutes and seconds. You take the number of minutes that she has sailed that measured mile, at top of page and if she had also taken several seconds besides the minutes, you look for the seconds at side; where they come together in the columns gives the speed of boat in nautical miles per hour.

I found that my cruiser made over the Deep Water Point measured mile course, the nautical mile in exactly 6 minutes. What is the speed of that boat per hour? Ans. 10 knots. Suppose she did the mile in 4 minutes and 20 seconds? Ans. 13.846 Knots per hour.

TABLE NO. 39 gives the True Amplitude. You must find the Latitude you are in, on the side columns and the Declination for the day at top of page. You then come down from the known Declination until you find the cross line to your Latitude, and this will give the True Amplitude.

Suppose we had Latitude 51° and Declination 12°, give the True Amplitude. Ans. 9° 18′. If you have seconds in either Lat. or Dec. you must interpolate.

TABLE NO. 40 gives the correction to what you found in Table No. 39 should you observe the Sun in the Visible Horizon. It is customary to observe the Sun when one diameter above the horizon to do away with this correction.

The correction is to be applied as follows. Rising in North Lat. and Setting in S. Lat. the correction goes to the Right and just the opposite in South Lat.

With Latitude 50° N. Declination 12° N. the correction is found to be 48′. Remember this table gives the quantities in tenths, so you must multiply by 6 to get minutes. The correction would be applied as per rule to the right if rising, and to the left if setting.

TABLE NO. 42 gives the logarithms of numbers. Find the logarithm for number 87. Ans. The log. required is less than 100, so find it on the first page of the logs. It is 1.93952. The index is One as shown.

Find log. for number 348. This log will be found between 100 and 1000. It is 2.54158. You find the log. on line with the number required and at top of page will be found, in this case, the number 0. You must add 2 for the index, as the number has three figures.

Now to find the logarithm of any number between 1000 and 10000, you must hunt in side column for the first three figures of your number and in line across page and under the next figure of your number from top of page, will be found the required log. Find log. for 1494. Ans. 3.17435. In this case you add 3 for the Index, as there are four figures in your number and the rule calls for one less for the Index.

Now let's find the log. for a number above 10000. Try 14956. Ans. The log. is found by securing the first three figures as before, then find the fourth figure from top of page. Now set down the log. so far found, and get the next larger. Take their difference and multiply by the last figure you have in your given number, and add it to the log. you set down first. 1495 gives us 17464. The difference between this log. and the next greater is 174. Point off the right-hand figure, making the number to be added to log. 17. This gives the required log. 4.17481. Notice that we have 4 as the Index, as there are 5 figures in the number. $174 = 29$ diff. $\times 4$.

To find the number corresponding to any given log. you work the rules just the opposite. You may multiply by these logs. Add the logs. of the numbers to be multiplied, then hunt up the log. of the sum for the answer.

Division by logs. From log. of the dividend subtract log. of the divisor; remainder will be the log. of the quotient.

TABLE NO. 44 BOWDITCH. This is one of the most important tables used by navigators. It shows the logarithmic function of all angles. Let's find log. sine of 75° 42′ and log. cosine of 14° 18′. Find the degrees at top or bottom of pages in right or left hand corners. Find the minutes in column marked M over or under the required degrees. The log. will be found where the degrees and minutes cross line. Log. sine of 75° 42′ is 9.98633 and the log. cosine of 14° 18′ is 9.98633. It will be noticed that the first log. is taken from bottom of page and the second log. taken from top of page. The minutes are taken from their respective columns.

USING SECONDS IN THE LOGS.: You must interpolate by the tables or use computation. Find the log. sine of 30° 10′ 19″. Ans. 9.70122. Here, you find the log. for 30° 10′ and find in the left-hand column M, the seconds 19″. Across line and under Diff. is found the number 7, to be added. Be careful to notice if the log. increases or decreases to apply the difference.

FINDING LOGS. FOR SMALL ANGLES AND INDEX 8. The differences vary so rapidly in this case, that no values will apply alike to angles on pages. On these pages the Diff. for 1′ is given and the seconds of arc, or the diff. for ″ must be found by computation. Let n stand for seconds of arc, d for the difference between the given log. and the next lesser. Let D stand for the difference between the next greater and next lesser log. That is the Diff. for 1′. The formula is $d = \frac{n}{60} \times D$. Give the log. sine of 4° 10′ 19″. Ans. 4° 10′ gives 8.86128 and 4° 11′ gives log. 8.86301. The difference is 173. Then we have $d = \frac{19}{60} \times 173$ gives 55, almost. Add this to log. sine of 4° 10′ gives us 8.86183 for the angle.

FINDING ANGLE CORRESPONDING TO LOGS. Take the same log. sine we have just found—8.86183—and find the angle. We know now that this can not be found by inspection, so we must work for it. The next lesser is 8.86128 and next greater is 8.86301. The Diff. for 1′ is 173. The difference between the given log. and the next lesser is 55. Then the formula is $n = \frac{55}{173} \times 60 = 19''$. We have now log. sine for 4° 10′ 8.86128 and 55 difference gives the required angle 4° 10′ 19″.

SMALL TABLE AT BOTTOM OF PAGES — . This table is used to get the difference in time between the given log, and the nearest log. in table. The difference is found in small table under the letters A. B. C. of columns and must be applied plus or minus according to the log. given being greater or less than the one found in tables. This is very important in taking out the correct time when securing the L. A. T. to work with the G. A. T. for Longitude.

THE HOUR COLUMNS are found at the left of the pages in this table and are of use in working the various formulae which involve functions of half the hour angle. Interpolation is made similar to angular measure. Sine ½ t is 9.91394. What is the Hour Angle A. M.? Ans., 7 hrs. 20 m. 43 s. The Hour Angle P. M. would be 4 hrs. 39 m. 7 s. This log. is not found, but the next lowest is 9.91389 with a difference of 5. This is found in column C. and 5 diff. giving, 5 seconds to be taken from the time of log. 9.91389.

BY COMPUTATION—What is the Hour Angle for sine ½ t 9.61400? Ans. This log. and the next lesser give a difference of 18. The next lesser and next greater logs. from the given log. show a difference of 29. Formula: $n = \frac{18}{29} \times 60 = 37''$. Remember, angle is ½ hour angle; 37″ × 2 gives us 74″; divided by 15, which gives us 5 seconds to be added to time corresponding to log. 9.61382, gives H. A. 3 hrs. 14 m. 13 s.

TABLE NO. 45 gives the log. haversine of Time. The hours and minutes are given at top of page and seconds in the left-hand column. Be sure to take out the light figures for your seconds, as the heavy figures are for the minutes of arc in the natural haversines on same pages.

Find the log. haversine of 1 hr. 3 m. 18 s. Ans. 8.27762. For 22 hrs. 55 m. 42 s. Ans. 8.29115.

Find the natural haversine for 31° 10′ 30″. Ans.: Top of page gives 31°, and down side column, left-hand side 10′, and half of the next minute, give nat. hav. 8.85857. The minutes are heavy type.

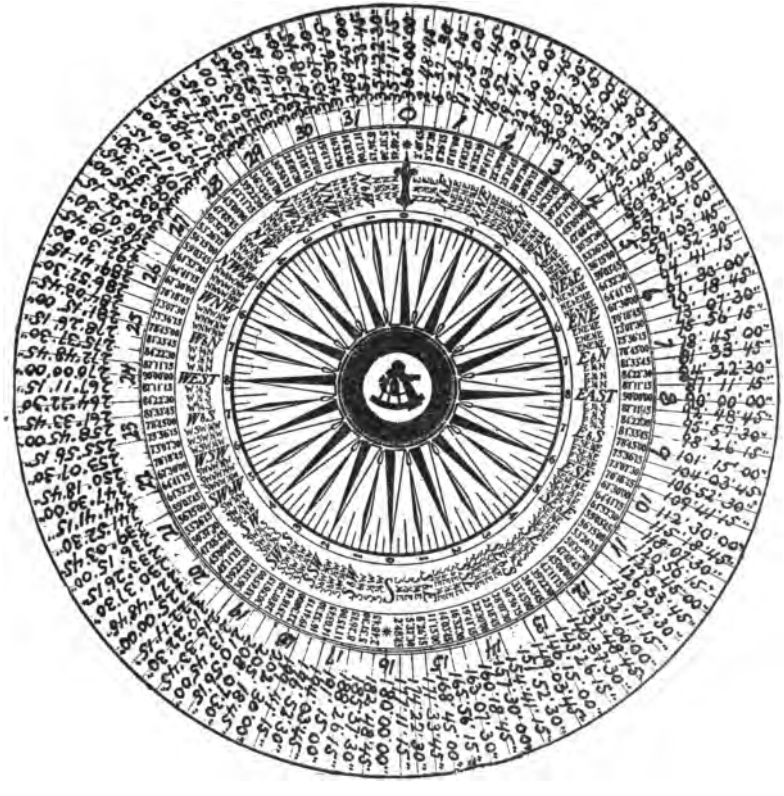
TABLE NO. 46 gives us the correction for the Observed Altitude to get the True Altitude. This table saves us from calculating the Refraction. Parallax, Dip and Semi-diameter. You must know the height of eye above the sea level, also your Index Error to sextant. After applying the sextant error, you look up the tables with height of eye and the Observed Altitude.

What is the correction to be applied to Altitude 32° H. E. 15 feet? Ans. 10′ 47″ for the sun to be added, and for a star 5′ 21″ to be subtracted. Now, if the date is given, you must use the small sun table at bottom. This is an additional correction to be applied for the sun's Altitude. Give the correction for May 15th. Ans., minus 8″ to what was found before.

THE NEW COMPASS CARD

The card shown here is too small to work from, but is given to show how easy all Compass Courses may be changed one from the other, by the use of this card. The advertisement of the card says it will be mailed to you for 50 cents.

The Compass Card has the Quarter Points, Half Points and Full Points given and their degrees, minutes and seconds of Arc. The full 360° are marked for each Quarter Point of the Compass. The Quadrants are given in 90° for working Traverse Tables that way.



WHAT ARE THE PROPER LIGHTS FOR A MOTOR BOAT AND EQUIPMENTS REQUIRED BY GOVERNMENT?

EQUIPMENT OF MOTOR BOATS REQUIRED BY THE NEW LAW

By an Act of Congress, approved June 9, 1910, which took effect July 9, 1910, **Motor Boats** are defined as "every vessel propelled by machinery, and not more than sixty-five feet in length, except tug boats and tow boats propelled by steam." The length shall be measured from end to end over the deck, excluding sheer.

Motor Boats are divided into three classes, as follows:

Class 1—Less than 26 feet in length;
Class 2—26 feet or over and less than 40 feet in length;
Class 3—40 feet or over and less than 65 feet in length;

and are required to carry the following equipment, under penalty of a fine not exceeding one hundred dollars. The motor boat shall be liable for said penalty and may be seized and proceeded against by way of libel in the District Court of the United States for any district within which such vessel may be found.

EQUIPMENT—CLASS 1

Lights—A white light aft, to show all around the horizon. A combined lantern in the forepart of the vessel, and lower than the white light aft, showing green to starboard and red to port.

Whistle—A whistle, or other sound-producing mechanical appliance, capable of producing a blast of two seconds or more in duration.

Life Preservers—Either life preservers, life belts, buoyant cushions, ring buoys or other device to be prescribed by the Secretary of Commerce and Labor, sufficient to sustain afloat every person on board, and so placed as to be readily accessible. If carrying passengers for hire, shall carry one life preserver, of the sort prescribed by the regulations of the Board of Supervising Inspectors, for every passenger carried.

Fire Extinguishers—Shall carry, ready for immediate use, the means of promptly and effectually extinguishing burning gasoline; besides the usual fire extinguishers, suitable chemicals, or bags of coarse flour or sand will serve the purpose.

EQUIPMENT—CLASS 2

Lights—A white light aft to show all around the horizon. A white bow light, with glass or lens not less than 19 square inches. One red, and one green, side lights with glass or lens not less than 16 square inches, and fitted with inboard screens not less than 18 inches long.

Whistle—Same as Class 1.

Fire Extinguishers—Same as Class 1.

Life Preservers—Same as Class 1.

Fog Bell—An efficient bell.

Fog Horn—An efficient fog horn.

EQUIPMENT—CLASS 3

Lights—A white light aft to show all around the horizon. A white bow light, with glass or lens not less than 31 square inches. One red, and one green, side lights with glass or lens not less than 25 square inches, and fitted with inboard screens not less than 24 inches long.

Whistle—Same as Class 1.

Life Preservers—Same as Class 1.

Fire Extinguishers—Same as Class 1.

Fog Horn—An efficient fog horn.

Fog Bell—An efficient bell, not less than eight inches across the mouth.

All lights prescribed above for Classes 2 and 3 must have fluted, or fresnal, lenses or glasses. The lights prescribed above are running lights and must be exhibited by all motor boats in all weathers from sunset to sunrise when under way. When at anchor between sunset and sunrise, all motor boats must carry anchor light as follows:

Anchor Light—A white light to show all around the horizon at a distance of at least one mile; this light must be carried forward, where it can best be seen, but at a height not exceeding 20 feet above the hull.

Pilot Rules—Motor boats are required to have on board two pamphlets of the pilot rules to be observed by them, which will be furnished by the local inspectors of steam vessels on request.

Copies of the Act of Congress making the above regulations for the equipment and operation of motor boats may be had from the following:

THE SECRETARY, BUREAU OF COMMERCE AND LABOR, Washington, D. C.

U. S. LOCAL INSPECTORS OF STEAM VESSELS, Post Office Building, Phila.

U. S. CUSTOM HOUSE, Chestnut Street, above Fourth, Phila.

COMPASS QUESTIONS AND ANSWERS

How do you apply W. Deviation and Variation for True Course? To the Left.

How do you apply E. Deviation and Variation for True Course? To the Right.

How do you apply W. Deviation to get Magnetic Course? To the Left.

How do you apply E. Deviation to get Magnetic Course? To the Right.

How do you apply W. Deviation and Variation to get Compass Course? To the Right.

How do you apply E. Deviation and Variation to get Compass Course? To the Left.

Where do we find the Deviation? In the compass, caused by the iron close to the compass.

Where do we find the Variation? On the Charts with amount given on the Compass Rose. Caused by the magnetism of the Earth.

What is the best way to find the Deviation of our compass? Get an adjuster to find it and give us a Deviation table after he has set his magnets to counteract most of the Deviation.

Can we find out the Deviation of our Compass? Yes, by the Azimuth problem or the Amplitude problems. Examples in this book.

What is best size and type of compass for a forty-footer? From 6 to 8 inches. Liquid.

How do we set a compass for steering? The Lubber Lines set in line with the keel.

How many Points has the Compass? It has 32 Points.

Name the Compass Points and Quarter Points. See Table in this book.

Does Deviation change? Yes. It changes rapidly in new boats, with a change of Latitude, collisions, heeling over, a cargo of iron, or being struck by a heavy sea.

Where is the North Magnetic Pole? In Lat. 70° N. Long. 97° W.

Where is the South Magnetic Pole? In Lat. 73° S. Long. 147° W.

Should the compass needle point to the Magnetic or True Pole? To the Magnetic Pole.

Does the Variation change? Yes. It changes during the day and is not the same for every location on the Earth's surface.

Name some places where this change takes place. Greenwich Var. W. 17°; West Indies Var. 0; Cape Farewell 48° W.; Cape Horn 19° E.; Hobart Town 10° E.; Canton 1° E.; Cape Good Hope 30° W.; Philadelphia 9° W.

DIFFERENCE OF LATITUDE AND DEPARTURE

What are the rules for getting Difference of Latitude?

Add the Diff. Lat. to Lat. Left if going towards the North and subtract the Diff. Lat. when going to the South or when in N. Lat. When in S. Lat., reverse this part of rule. Add when Lat. and Diff. Lat. have same names and subtract when they have different names and give name of the larger.

Examples—Latitude left 39° 20′ 40″ N. Diff. Lat. 19′ N. Ans. 39° 39′ 40″ N.

Lat. left 40° 30′ 50″ N. Diff. Lat. 20′ 20″ S. Ans. 40° 10′ 30″ N.

Lat. left 0° 30′ 20″ N. Diff. Lat. 40′ 40″ S. Ans. O° 10′ 20″ S. Crossed the Equator.

FINDING THE DIFF. LAT. AND DEPARTURE

Where do we find the Diff. Lat. and Dep.?

In the Bowditch Table No. 2. We find the course, True, and use the given distance sailed on that course and find across line, the Diff. Lat. and Dep. corresponding to Distance and Course.

How do we apply the Departure to secure the Diff. Longitude?

Get the Middle Latitude by adding the Lat. left and the Lat. In, and divide by 2. Find this quantity as a course and use the Dep. in the Latitude Column. The Distance column will give the Diff. Long. It is to be applied in accordance with the change of Long. on the run. What would be the Diff. Long. on the following courses? Departure given as 40′? Course 49°—Ans. 61′. Course 27°—Ans. 88′. Course 200°—Ans. 42′ 30″. Course 279°—Ans. 256′.

How would we apply this Diff. Long.?

If the Long. Left was West and we had a Diff. Long. W. it would be added to get the Long. In. If the Long. Left was W. and we had Diff. Long. E. it would be subtracted. In both cases the Long. In, would be named West, without we had crossed the Meridian of Greenwich from W. Long. to East Long.

Are there any kinks in taking out the Diff. Long. Dep. and Diff. Lat. from the tables?

You bet. If the course is given at bottom of page you must get the Diff. Lat. in the opposite column from that of top of page. All the quantities must be taken the same way.

PARALLEL SAILING

What about taking out the Departure when we are sailing on a certain Parallel of Latitude? Then you use the Latitude you sail on as the Course, and get the Dep. in the Latitude column for the Diff. Long.

Suppose you were sailing True North or South, what would be the Diff. Lat. after sailing a certain distance?

The distance sailed would be the whole Diff. Lat. Applied like the other rules for Diff. Lat.

EXAMPLES—Latitude Left, 38° 40′ N. Sailed True North for 60′ Ans. Lat. In, 39°.40′ N.

Lat. Left., 40° 20′ N. Sailed 60′ S. Ans. Lat. In, 39° 20′ N.

Lat. Left, 10° 20′ N. Sailed South, True 620′. Ans. On the Equator.

Lat. Left, 1° 20′ S. Sailed N. True, 100′. Ans. Lat. In, 0° 20′ N.

Lat. Left, 0° 30′ N. Sailed S. True, 90′. Ans. Lat. In, 1° 0′ S.

Parallel 55° sailed 300 E. Give Diff. Long. Ans. 8° 43′ E.

Parallel 55° ship sails 300 miles Diff. Long. What is Departure? Ans. 171.1.

On what parallel must a ship sail 150 miles E. to change her Long. 300′? Ans. 60°.

From Long. 3° 12′ W. sailed E. 246 miles. By observation, ship is in Long. 40° 8′ E. What was the Parallel she sailed? Ans. 56°.

Long. Left, 74° 34′ 33″ W. Sailed Parallel 39° distance 40 Miles E. as Departure. What is the Long. In? Ans. 73° 43′ 33″ W.

Show rule of Logs. for working the third example above. Ans. 246 miles as Dep. find log. and add 10 to Index, making it 12. The Diff. of Long. of the two places equals 440′. Find the log of same. Add the logs and find the Cosine of sum. Ans. 56°.

THE CHART

Name several types of charts. Mercator, Polyconic, Gnomonic, Wind charts, Tide charts, Variation charts, Storm, and Weather charts, Pilot charts.

Give description of Mercator chart. The chart is projected on a plane surface as if a cylinder had been unrolled with lines marked on it to show the Latitudes and Longitudes. This has caused the enlargement of the Latitudes as they go to the North but the Longitudes are kept the same distance apart.

This chart may be constructed by knowing the rules of Meridional Parts, Table 3 Bowditch.

Give description of Polyconic Chart. This chart is projected as from a cone. It gives the Latitude and Longitude in their true lengths.

Give description of Gnomonic Chart. It is supposed that the eye of the spectator is situated at the centre of the sphere, where, being at once in the plane of every great circle, the eye will see all circles as straight lines. In this chart, the straight line between two places represents the arc of a great circle, and is therefore the shortest line between the points. This chart is used for Great Circle Sailing.

Where can we get Tide Charts? From the Government.

What is the use of the Variation Charts? They give the Variation for every part of the globe with the annual change. With these charts the navigator may know his Variation to a nicety when sailing from port to port.

Give description of Mercator Chart for reading off the Latitude, Longitude, and other information. Ans.—The chart has North at top, Latitude lines run across chart, Longitude lines run up and down. Light vessels are marked on coast charts, Distance is given in scale, Latitude on sides of charts may be used as miles when wanting distance sailed, but use the Latitude of place you are sailing as the lines decrease as we go North and would make the distance too small should we use a higher Latitude than we were sailing in. The chart has a compass generally showing Magnetic. Some charts are made True. That would make the North point of the Compass Rose on the chart, up and down with the Meridians of Longitude. Depth is given with character of bottom. Fathom Lines are marked to show depth in fathoms, Variation is given on side of Compass Arrow with annual change. Description of lights are generally given. Buoys are shown. All dikes, ledges, lighthouses, piers, range lights, light vessels, and day marks are shown.

MERIDIANS ADOPTED

Give the Meridians adopted by the different governments. Ans. The U. S. charts use Meridian of Greenwich; so do Argentina, Austria, Belgium, Brazil, Chile, Denmark, Germany, Great Britain, Holland. The Russian charts use Pulkowa Observatory in Long. 30° 19′ 40″ E. of Greenwich. The French charts, the Observatory of Paris for their Prime Meridian in Long. 2° 20′ 14.6″ East of Greenwich. Some of the Dutch charts are reckoned from the Meridian 4° 53′ 01.5″ E. Portuguese charts use Lisbon Castle in Long. 9° 07′ 54.86″ West of Greenwich. Spain uses San Fernando Observatory at Cadiz. Long. 6° 12′ 18″ West of Greenwich.

BOTTOM MARKINGS AND ABBREVIATIONS. Charts of U. S.

Clay—C, Coral—Co, Gravel—G, Mud—M, Rocky—rky, Sand—S, Shells—Sh, Stone—St, Weed—Wd, Fine—fne, Coarse—crs Stiff—stf Soft—sft, Black-bk, Red—rd, Yellow-yl, Gray—gy.

EXAMPLES ON CHART

How do you find the Latitude and Longitude of a place on the chart? Ans. I would take the dividers with one leg on the Latitude line below the place and measure with the other leg to the place. Measurements taken up and down of chart. For the Longitude, I would measure with the dividers from the side Meridian of less Longitude than place to the place, remembering that Longitude lines run up and down the chart, but measurements are taken across chart.

GIVE LATITUDE AND LONGITUDE of the following places.

Ambrose Channel Light Vessel—Ans. 40° 27′ 59″ N. 73° 50′ 02″ W.
Overfalls Light Vessel—Ans. 38° 47′ 57″ N. 75° 01′ 24″ W.
Cape Charles Light Vessel—Ans. 37° 05′ 17″ N. 75° 43′ 29″ W.
Diamond Shoals Light Vessel—Ans. 35° 05′ 08″ N. 75° 19′ 38″ W.
Charlestown Light Vessel—Ans. 32° 40′ 59″ N. 79° 43′ 41″ W.
Brunswick Light Vessel—Ans. 31° 00′ 10″ N. 81° 09′ 35″ W.
Cape Canaveral Light—Ans. 28° 27′ 37″ N. 80° 32′ 37″ W.
Heald Bank Light Vessel—Ans. 29° 06′ 05″ N. 94° 12′ 27″ W.

WHAT DEPTH OF WATER CAN BE EXPECTED AT THE FOLLOWING PLACES?

McCries Shoal Gas and Whistle Buoy—Ans. Eleven fathoms.

North East End Light Vessel—Ans. Fourteen fathoms.

Five Fathom Bank Light Vessel—Ans. Fifteen and a half fathoms.

Scotland Light Vessel—Ans. Ten and a half fathoms.

Cornfield Point Light Vessel—Ans. Twenty-seven fathoms.

Bartlette Reef Light Vessel—Ans. Eleven fathoms.

Ram Island Reef Light Vessel—Ans. Ten fathoms.

Brenton Reef Light Vessel—Ans. Fourteen fathoms.
Vineyard Sound Light Vessel—Ans. Seventeen fathoms.

GIVE THE COURSE AND DISTANCE BETWEEN PLACES

From Overfalls Light Vessel to Fourteen Foot Bank Lighthouse—Ans. N. X. W. ½ W. 16¾ miles.

Cape Charles Light Vessel to Cape Henry Gas Buoy—Ans. S. W. ½ W. 12¼ miles.

Thimble Light to Old Point—Ans. W. X. S. 3 miles.

Overfalls Light Vessel to Elbow Cross Ledge—Ans. Twenty-six miles, about N. N. W. ¼ W.

Winter Quarters Light Vessel to Cape Charles Light Vessel—Ans. 216° True, 63 miles.

Cape Charles Light Vessel to Diamond Shoals Light Vessel—Ans. Course 170° True, 122 miles.

North East End Light Vessel to Fire Island Light Vessel—Ans. Course 34° True, 109 miles.

SOUNDING IN FOG FOR POSITION

Do you know how to find your position by sounding in a fog? Give examples.

Cruiser is making a port or harbor and fog comes on. I would let go the lead-line on course that was supposed to take me to destination and find the depth of water and also get the character of the bottom. I would mark this down on transparent paper or glass (using grease pencil) and then sail for a certain distance and time and then sound again. With the next sounding and test of the bottom known, I would sail again for time and distance, and again sound. After four or five soundings I would have a line of soundings to lay on my chart in my supposed position and should these soundings on glass or transparent paper correspond, I would feel sure I was on my course. If it was advisable to change course, I would do so to reach port.

What instrument would you use to take cross bearing and bow and beam bearing?

I would use the Cole Bearing Finder as it is a small compass made especially for that purpose. It has a reflecting glass that raises the compass card and Lubber Line so that the Line may be pointed at object and course read off clearly.

What do you think best for laying off the courses on the chart?

By all means the Cole Protractor. It is flexible and true and does not have to be moved like the Parallel Rulers which are so apt to slip and give a wrong course on the chart.

What other means are there for getting bearing of objects and plotting the point bearing?

The Hands and Sons Traverse Card. It gives all bearing in quarter points that an object is bearing and at a glance you may give the distance from the object and know how far to sail before the object will bear on some other course or points. It is one of the finest graphic methods so far gotten up for this work and saves a lot of figures and plotting on the chart.

OBSERVATIONS WITH ARTIFICIAL HORIZON

Bring lower limb of Sun down to meet the Sun in the Art. Hor. read off the Arc of sextant, subtract or add the Index Error of sextant, then divide by 2. Remember there is no DIP when using the Art. Hor. so you apply the Refraction, Parallax and Semi-diameter to get the True Altitude. When using the stars, you must bring the star down with the sextant until it covers the star in the Art. Hor. No DIP or PARALLAX, just take out the Refraction after you have applied your I. E. and divided the Obs. Alt. by 2. Don't apply Semidiameter.

EXAMPLES: Sun, L. L. brought down, May 15th. Obs. Alt. from Art. Hor. 80° 20′ I. E. minus 2′ give the True Alt. Ans. T. Alt. 40° 23′ 49″. June 20th. Obs. Alt. from Art. Hor. 70° 20′ 40″ I. E. 2′ 20″ plus. Ans. True Alt. 35° 26′ 01″.

OBS. ALT. OF STAR WITH ART. HOR. May 1st. Obs. Alt. from Art. Hor. 65° 24′ 30″ I. E. 20″ minus, give the T. Alt. Ans. 37° 40′ 50″.

GETTING THE LATITUDE

This may be done by several methods as follows—Meridian Altitude of the Sun at noon or by Star passing the Meridian, St. Hilaire method, Ex. Meridian, and Single Altitude and Time problems.

MERIDIAN ALTITUDE METHOD FOR SUN: Get the Observed Altitude by the sextant and correct it for Index Error of your sextant, hunt up the Dip, the Refraction, Parallax, and Semidiameter and apply them to Observed Altitude for True Altitude. Subtract the True Alt. from 90° and mark the remainder N. or S. by the rule which says, "Sun S. of observer the Z. D. is N. If N. of observer, Z. D. is S." Now apply the Declination, after it has been corrected for the number of hours past noon at Greenwich, to this remainder or Zenith Distance, and if of same name as Zenith Distance, you add and if of other name, you subtract the Declination (or the Z. D.) and give the name of the greater. This gives the Latitude.

GIVE THE LATITUDE

EXAMPLES: Sept. 23rd. Obs. Alt. 71° 19′ 20″ S. I. E. plus 3′ 40″ H. E. 18 ft. Cor. Dec. 0° 0′ 15″ N. Ans. Lat. 18° 25′ 42″ N. Feb. 12th. Obs. Alt. 29° 55′ 20″ S. I. E. minus 1′ 10″ H. E. 19 ft. Cor. Dec. 13° 34′ 16″ S. Ans. Lat. 46° 21′ 7″ N. Jan. 10th. Obs. Alt. 68° 39′ 40″ N. I. E. plus 5′ 10″ H. E. 13 ft. Cor. Dec. 21° 56′ 1″ S. Ans. Lat. 42° 58′ 44″ S. April 28th. Obs. Alt. 82° 51′ 10″ N. Upper Limb of Sun. I. E. 4′ 10″ plus H. E. 18 ft. Cor. Dec. 14° 17′ 37″ N. Ans. Lat. 6° 52′ 17″ N. Don't forget to subtract the Semidiameter from the Obs. Alt. when the Upper Limb of the Sun is brought down to the Horizon. March 21st. Obs. Alt. 76° 58′ 15″ N. Lower Limb. I. E. minus 2′ 20″, H. E. 21 ft. Cor. Dec. 0° 16′ 37″ N. Ans. Lat. 12° 36′ 03″ N. July 13th. Obs. Alt. 68° 02′ 20″ N. I. E. minus 2′ 16″, H. E. 17 ft. Cor. Dec. 21° 48′ 32″ N. Ans. 0° 0′ 0″ ship is on the Equator. Sept. 23rd. Obs. Alt. 40° 09′ 00″ N. I. E. 1′ 40″ plus, H. E. 18 ft. Cor. Dec. 0° 0′ 0″. Ans. Lat. 49° 39′ 52″ S. Feb. 25th. Obs. Alt. 40° 41′ 10″ S. I. E. 1′ 20″ minus, H. E. nothing as Art. Horz. was used. Cor. Dec. 9° 7′ 6″ S. Ans. Lat. 39° 57′ 54″ N.

LATITUDE BY STAR SIGHT

Find the time the star will be on the Meridian by table of stars in Nautical Almanac under heading "Meridian Transit of Stars." This table gives the time of the stars as they pass the Meridian of Greenwich with small table for correction of the date. It stands to reason that these same times will be the meridian Passage of the stars at any other place on the earth's surface. If the Meridian of Greenwich has a star in line at 8 P. M. the 75th Meridian W. will pass that star at the same time, but it will then be 1 A. M. at Greenwich. It must be remembered that the stars do not move. They are practically stationary. Say the same star was on the 75th E. Meridian at 8 P. M. Then it would be only 3 P. M. at Greenwich and the star would be waiting for the old earth to turn Greenwich Meridian in line with it, which would occur at 8 P. M. Now, Greenwich has the star on its Meridian, and, as we stated before, the 75 W. Meridian would be going like a rocket, east, to be on deck at 8 P. M. and have that same star on its Meridian.

LATITUDE BY STAR ON MERIDIAN. You get the Obs. Altitude by sextant and Art. Hor. if on shore and by sea horizon if at sea. Correct this by rules given to the True Alt. and then subtract from 90° for the Z. D. Now you must apply the Star's Declination, to get the Lat. There is no correction for the Declination of stars. Just take it from the Nautical Almanac and be sure to notice if it is N. or S. If Dec. and Z. D. are both S. or N. you add for Lat. If of different names, subtract and give the name of the greater for Lat.

EXAMPLES: GIVE THE LATITUDE—Obs. Alt. with Art. Hor. Feb. 67° 01′ 20″ S. I. E. 1′ 10″ minus, Star is Sirus. Ans. Lat. 39° 55′ 13″ N. The Obs. Alt. of the star Androm 76° 10′ 30″ S. index E. plus 27″ H. E. 25 ft. month. Nov. Ans. Lat. 42° 32′ 42″ N. August. Obs. Alt. of star Vega 50° 00′ 20″ N. No index error, H. E. 22 ft. Ans. Lat. 1° 22′ 34″ S.

FIND THE LATITUDE

EXAMPLES: Noon at ship, Dec. 15th, 1917. C. T. 7h. 51m. 21s. A. M. Obs. Alt. of Sun above Pole 30° 27′ 00″ N. L. L. was observed. H. E. 18 ft. No index error. Give Lat. Ans. Cor. Dec. 23° 15′ 14″ N. Lat. 82° 37′ 36″ S. at Noon.

Obs. Alt. Sun's L. L. below the Pole 15° 45′ 30″ S. H. E. 18 ft. C. T. 7h. 51m. 21s. P. M. Cor. Dec. 23° 16′ 51″ S. Give Lat. same date as other ex.

Ans. As the Sun is below the Pole, you must get the Polar Distance by subtracting the Cor. Dec. from 90°. True Alt. 15° 54′ 25″ S. Lat. 82° 37′ 34″ S. P. D. is added to True Alt. to get Lat.

Obs. Alt. Sun's L. L. 72° 48′ 00″ S. Corrections to Obs. Alt. 10′ 55″, plus Cor. Dec. 17° 01′ 05″ S. Give the Lat. Ans. 00° 00′ 00″ on the Equator.

March 21st, 1917. The Obs. Alt. S. L. L. 89° 47′ 10″ S. Semidiameter 16′ 05″ plus, Dip 3′ 15″ minus, Ref. and Pax. 00′ 00″. Cor. Dec. 00° 00′ 00″. Give the Lat. Ans. On the Equator.

June 20th, 1917. Obs. Alt. S. L. L. 23° 18′ 00′ S. Sem. Dim. 15′ 46″ plus, Dip 5′ 00″ minus, Ref. Pax. 2′ 05″ minus. Cor. Dec. 23° 26′ 41′ N. Give the Lat.

Ans. 90° 00′ 00″ N. At the North Pole.

LATITUDE BY ALTITUDE OF STAR: The Meridian Passage of Stars is given in the N. A. with corrections for the days of the month. Select the star that will be on your Meridian. Find its Declination and use the Lat. by D. R. to secure the Z. D. If Lat. and Dec. are same name, their difference is the Z. D. When they are of different names, the sum is the Z. D. In either case subtract Z. D. from 90° to secure the True Alt. for setting the sextant for the Approximate Altitude.

EXAMPLES: Lat. 40° 50′ 00″ N. Star's Dec. 20° 30′ 00″ N. gives Z. D. 20° 20′ 00″ N. T. Alt. 69° 40′ 00′ S. Lat. by D. R. 50° 20′ 40″ S. Star's Dec. 16° 20′ 30″ N. gives Z. D. 66° 41′ 10″ S. T. Alt. 23° 18′ 50″ N.

STARS BELOW THE POLE: Find the star's Declination and subtract it from 90° and call it Polar Distance. P. D. Subtract P. D. from the Lat. by D. R. for True Alt. to set the sextant for Obs. Alt. If you wish to reverse the signs of Dip. Ref. and I. E. and apply to True Alt. you will come nearer to the Obs. Alt. on the sextant.

EXAMPLE: Lat. by D. R. 64° 59′ 00″ S. Star's Dec. 62° 38′ 21″ S. gives P. D. 27° 21′ 29′ S. P. D. from Lat. gives True Alt. 37° 37′ 31″ S. Dip 4′ 09″ plus. Ref. 1′ 15″ plus, I. E. 2′ minus, gives Obs. Alt. 37° 40′ 55″ S. All signs reversed to get Obs. Alt. on sextant.

Obs. Alt. star Androm. 64° 36′ 30″ S. cor. to Obs. Alt. 6′ 39″ minus, Dec. 28° 36′ 56″ N.

Ans. Latitude 54° 07′ 05″ N.

Meridian Passage of the star Achernar 16h. 10m. 12s. Obs. Alt. 50° 32′ 45″ S. cor. minus 4′ 58″. Dec. 57° 40′ 25″ S.

Ans. Latitude 18° 08′ 12″ S.

Star Sirus on the Meridian from the N. A. in M. T. 16h. 18m. 00s. Obs. Alt. 41° 36′ 20″ S. I. E. 4′ 30″ on the arc. Dip 5′ 11″ minus, Ref. 1′ 06″ minus. Dec. 16° 35′ 51″ S.

Ans. Latitude 31° 58′ 36″ N.

Capella's Dec. 45° 54′ 54″ N. sub. from 90° gives P. D. Obs. Alt. of star below the Pole. 21° 30′ 00″ N. cor. to Alt. 7′ 50″ minus.
Ans. Latitude 65° 27′ 16″ N.

LATITUDE BY MERIDIAN ALTITUDE OF PLANETS: Now we come to the Planets and don't get rattled. It takes just a little longer to find the Declination, the M. T. the Planet will be on your Meridian, and the True Altitude, if you work to seconds for the corrections. If you take from the N. A. the Quantities as set down and ignore some of them, you may get your Latitude just as quickly as in the Sun method. The Long. is required, the Obs. Alt. the Dec. the corrections to the Obs. Alt., and the M. T. the Planet will be on your Meridian.

QUANTITIES FROM THE ALMANAC: The fifty-cent yellow bound N. A. gives the correction of Dec. of Planets for 24 hours. If you will place a decimal point between the last two figures given on the side, and between two Decs., you will find that you have the change of Dec. in minutes and seconds of arc. The first figures will be minutes and the other figures tenths of a minute, to be multiplied by six to get seconds. Try it this way and find out. Take the difference between two days for the Dec. The reason the figures for 24 hour difference are put down as they are is to allow you to refer the number to Table IV of the N. A. with the number of hours after Greenwich Noon, to find the change of Dec. by inspection. This way comes within a second, or not much over 3 seconds of arc of being exact.

MERIDIAN PASSAGE OF THE PLANET: This is given in the N. A. for G. M. T. You may use that as the M. P. of your place and it will not make any difference in the Lat. Should you wish to work it to the second, Take the difference between the day of sight and the next, and change into seconds and divide by 24. Now multiply what you get by the Long. in time, and add or subtract what you get again, to or from the Meridian Passage at Greenwich for your L. T. of Passage. This same time may be used to correct the Dec. of the Planet, or you may just use the Long. in time and multiply by the H. D. (hourly Difference) or, again, take the small figures alongside of the Dec. and your Long. in time, and find where they come together in Table IV of the N. A. for the correction, which is to be added or subtracted the same as the rules for Dec. of the Sun.

PLANET'S RIGHT ASCENSION: Another way to find the Meridian Passage of the Planet is to get the correct Right Ascension of the Planet for the time of sight, also the Cor. M. S. R. A. and subtract the Sun from the Planet's R. A., even should you add 24 hours to make the subtraction. This gives the M. P. at your window, roof or any old place you may be, and will be very close to what is set down already in the N. A. for the passage at G.

TO CORRECT THE OBS. ALT. OF A PLANET: Nothing hard about it. Apply the Index Error of the sextant, dig up the Dip for H. E. and the Refraction and apply, like for the Sun. In the N. A. will be found the Horizontal Parallax, which amount to very little, but it is supposed to be corrected to Alt. Pax. To do it, you hunt for your A. Alt. side column, and under Hor. Pax. in line will be found the Alt. Pax. to be added to give you the True Alt., using Table 17 Bowditch. The semidiameter is so very small, it may be dropped, but you can apply it from the bottom of the page in the N. A.

EXAMPLES: Feb. 20th, 1917. Planet Jupiter, Transit Meridian of G. 3h. 58m. On the next day it is 8h. 55m., so you see it is decreasing in time. The difference for one day is 3m. divided by 24 gives us 7.5s. (3m. were changed into s.) Now multiply by the Long. in time, 5 hrs. we will say, and the amount subtracted from the G. P. of the Planet, gives the L. M. T. of passage, or 3h. 57m. 22.5s. Now try it with the Planet's R. A., which is 1h. 58m. 03s., and correct by the little figures alongside in Table IV of the N. A. gives us, 8s. to be sub. or 1h. 58m. 11s. as the R. A. is increasing.

Now try it with the Sun's M. R. A. with cor. gives for the date and 5 hrs. of Long. 22h. 00m. 12.8s. Subtracted from the Planet's R. A. gives 3h. 57m. 58.2s. for the M. P. Had you taken out the Passage of the Planet at once, you can see it would have made very little difference in the passage of that planet.

The small figures alongside of the Planet's R. A. are seconds of difference for 24 hrs.

DECLINATION OF PLANET: We have for Jupiter Dec. 10° 58′ 00″ N. on Feb. 20th, 1917. Correction for 24 hrs. alongside of the Dec. gives 38. Place a decimal point between the figures and you have 3′ 48″ as the .8 is tenths of a minute, or as put down, for seconds of arc.

This number 38, found in Table IV of N. A. and Long. 5 hrs. gives cor. of .8 to be added to Dec. If you had used the L. T. of Passage, or 3h. 58m. and the same number in table, it would give you .7″.

Remember when taking out the correction for the Dec. that Table IV gives minutes and tenths. Place a decimal point before the last figure in the quantity found and you have minutes and seconds, but, as stated, the seconds are found by multiplying the tenths by 6.

GETTING LATITUDE BEFORE AND AFTER NOON BY THE EX MERIDAN PROBLEM

The Apparent Time is noted before or after Noon, but it must be remembered that you can use Tables 26-27 of Bowditch only to 26 minutes before or after Noon.

The Observed Altitude is secured and corrected to the True Altitude.

The Declination is taken from the Nautical Almanac for the day and corrected up to Noon. Table 26 of Bowditch gives the correction for one minute and Table 27 gives the correction for the number of minutes after or before the Sun or Star is on the Meridian. This quantity is to be added to the True Altitude. Be sure you apply the index error of your instrument.

Work the Latitude problem just the same as you do for the Meridian Altitude to secure the Latitude.

EXAMPLES: Jan. 2nd P. M. The G. A. T. is 5h. 00m. 22s. Obs. Alt. Sun's L. L. 60° 24′ 30″ N. I. E. plus 2′ H. E. 15 ft. Cor. Dec. 22° 52′ 30″ S. Lat. by D. R. 52° 10′ 00″ S. Long. 70° 50′ 30″ W. Time past Noon 17 minutes A. T. Give the Lat. by Ex. Meridian problem from Tables 26-27. Ans. 52° 02′ 55″ S.

Suppose we wished to try this observation from a window at home or from the roof, how would we get the G. A. T.? Ans. By turning our L. M. T. into L. A. T. by applying the Eq. of Time, from the Nautical Almanac, with correction for the number of hours after Noon at Greenwich, to the L. M. T. Then adding the Longitude to the L. A. T. to secure the G. A. T. In the example just given we have by watch, after correction, 12h. 21m. 8s. P. M. The Eq. of T. for the Long. 4h. 43m. 22s. and the 21m. 8s. or the time after Noon at G. is 4m. 8s. minus. Making our L. A. T. 12h. 17m. 00s. P. M. or 17 minutes after Noon.

July 5th. A. M. Obs. Alt. Sun's L. L. 40° 20′ 00″ N. H. E. 15 ft. I. E. minus 20″ Long. 60° W. Lat. by D. R. 26° 30′ 00″ S. Cor. Dec. 22° 48′ 48″ N. Time before Noon M. T. by watch, after correction, 25m. 17s. Give the Lat. by Ex. Meridian Tables 26-27 Bowditch. Ans. Lat. 26° 24′ 06″ S.

How did we get the Greenwich Date to correct the Declination and Equation of Time?

Ans. To the L. M. T. expressed Astronomically, we add the Long. in Time as we are West of Greenwich. Astronomical Time at Place, Ship, Roof Garden, Roof or Window, all meaning the same. July 4d. 23h. 34m. 43s. M. T. Adding the Long. gives us July 4d. 27h. 34m. 43s. Now take away 24 hrs. and give the date a day ahead, making our G.D. July 5d. 3h. 34m. 43s. M.T. This give us the dope to get the proper Eq. of T. and the Dec. Take them for the date given and correct them for the number of hours after Noon at Greenwich. This gives us 4m. 17s. Eq. of T. to be subtracted from our L. M. T., which causes our Time before Noon to be 21m. Look up Table 26 Bowditch and take out the seconds for columns that give the Lat. by D. R. and the Cor. Dec. It is 2.1″. Now find this in Table 27 Bowditch for the full correction of Time before Noon. It is 15′ 26″ plus to Alt.

Oct. 18th, 1917. A. M. at Ship. Lat. by D. R. 44° 52′ N., Long. 45° 44′ W. Obs. Alt. the Star Procyon, off the Meridian, 50° 10′ S. H. I. 26 ft. C. T. Oct. 17d. 20h. 27m. 20s., which was fast on G. M. T. 3m. 42s. Give the Latitude by Reduction to the Meridian.

This example requires the L. S. T. and the Star's Right Ascension to secure the Hour Angle. Correct the Chronometer Time, subtract the Long. gives us M. T. S. of given day (17d.). Dig up the M. S. R. A. and the correction for the number of hours after Noon at G. and add them to the L. M. T. (M. T. at S.). This gives us the L. S. T. From this time subtract the Star's R. A. or subtract from the Star's R. A. if greater, for the H. A. and be sure you remember to mark down, if the H. A. is E. or W., meaning your Local Sidereal Time is greater or less than the Star's Right Ascension. If your L. S. T. is more, star is to the West of your Meridian, as the old Earth has passed that star by the quantity of H. A. If your L. S. T. is less, then you have to wait the quantity of H. A. before the star would be on your Meridian, as star is East. This Hour Angle is the Time before or after Meridian Passage of the Star, meaning the same thing as before, or after Noon with the Sun, as we are figuring the angle on either side of the Meridian to get our Latitude. We then have from the problem, H. A. or time before star will come to Meridian 29m. 17s. This is too great for the tables 26-27.

Tackle the Ex. Meridian problem to secure the correction to the Obs. Alt.

RULE—Add the logs. Constant Log. 0.30103, Cosine of the Latitude, Cosine of the Declination, Cosecant of the Zenith Distance and TWICE the Sine of the Hour Angle. Then find the Sine of the Sum of the Logs for the Correction to be ADDED to the True Altitude.

Again—How do we find the Zenith Distance? Ans. If the Lat. and Dec. have same names, subtract for Z. D., and if of different names, add for Z. D.

How de we get TWICE the Sine of the H. A.? Ans. Find the Sine of the H. A. and multiply by 2, BUT, keep only the last figure of the Index to add with the logs. In this example, the Sine of 29m. 17s. (found Table 44 Bowditch) is 8.80513, and TWICE the Sine is 7.61026. Notice that you drop the first figure of the Index when multiplying by 2.

The Sine of the Sum of the logs is 7.95692, which gives the correction for the Alt. 31′ 10″ to be added.

Now you get the correction for the True Altitude, Table 46 Bowditch for Star; subtract True Alt. from 90° and name it Z. D., with name opposite of bearing when observation was taken, and apply the Declination. Ans. Dec. of Star is 5° 26′ 18″ N. Z. D. 39° 24′ 37″ N. Lat. 44° 50′ 55″ N.

1917, July 20th. A. M. at Ship in Lat. by D. R. 10° 15′ N., Long. 150° 30′ E. The Obs. Alt. of star Cygni or Deneb, 55° 6′ 40″ N. I. E. 1′ 12″ minus, H. E. 29 ft. C. T. 19d. 1h. 59m. 24s., which had been found to be slow 29m. 28s. of M. T. at S. Run since error was determined, S. W. ¾ S. 40 miles. Give the Latitude by Reduction to the Meridian or Tables 26-27 Bowditch.

Answer. C. C. T. 19d. 2h. 28m. 52s. The run S. W. ¾ S. 40 miles, must be used in the Traverse Tables to secure the Diff. of Long. This quantity is subtracted from the C. T. as the ship has changed her position towards the West and made her time earlier than the Longitude used in the problem. Diff. Long. 1′ 36″. G. M. T. now is 19d. 2h. 27m. 16s.

The Long. East, equals 10h. 2m. 00s. Subtracted from G. M. T. gives the L. M. T. Add the M. S. R. A. with corrections for G. M. T. for your L. S. T. Equals 20h. 16m. 30s. Star's R. A. is 20h. 38m. 39s. Hour Angle is 22m. 9s. Star is East of the Meridian.

Table 26 Bowditch gives for Lat. 10° 15′ N. and Dec. of Star 44° 59′ N. 2.4″. Table 27 gives for the H. A. and 2.7″ from Table 26—19′ 39″ as the correction to be added to the True Alt. True Alt. 55° 19′ 09″ N., Lat. 10° 18′ 09″ N.

1917, June 1st. A. M. at Ship. Lat. by D. R. 50° 20′ N., Long. 20° 34′ W. The Obs. Alt. of the star Antares near the Meridian, 13° 20′ 00″ S. H. E. 17 ft. Time by watch 1d. 12h. 10m. 30s. Fast on M. T. at S. 1m. 11s. Diff. of Long. made since the error was found is 19 miles to the westward. Give the Lat. by reduction to the Meridian or Table 26-27 Bowditch.

Answer. Diff. Long. 19′ equals 1m. 16s. in time. Watch fast 1m. 11s., so take off both times from Watch and add 12 hours as the time is A. M. Correct Watch Time May 31d. 12h. 8m. 3s. Notice that we have set the day one back, but not added 12 hrs. If you will think for an instant, you will see that date June 1st, Civil Time, is 12 hours ahead of May 31st, Astronomical Time, so the time stands, but date is changed.

Long. W. added to W. T. gives G. D. May 31d. 13h. 30m. 19s. Get L. S. T. by adding the M. S. R. A. with correction for the G. D. L. S. T. 16h. 43m. 50s.

Star's R. A. 16h. 24m. 23s. Hour Angle 19m. 27s. Star is W.

Table 26 gives 1.2″ Table 27 gives 7′ 36″ to be added to True Alt.

True Alt. 13° 19′ 36″. Dec. of star 26° 15′ 6″ S. Lat. 50° 25′ 18″ N.

SINGLE ALTITUDE AND TIME FOR LATITUDE

The method is a good one to secure the Latitude when the hour angle is more than the Bowditch Tables 26-27 for the Ex. Meridian problem.

The Chronometer Time is required which gives the G. D. The Equation of Time is applied to L. M. T. to secure the L. A. T. and then the time from or after Noon is found. This number of hours, minutes and seconds is to be turned into arc and called T. The exact time of observation must be known to secure the time before or after noon. With stars, use H. A.

The Corrected Declination is required and the True Altitude. Find the Secant of the H. A. or T.=time before or after noon with Sun, and time either side of Meridian with star, called H. A. The Tangent of the Cor. Dec. also the Cosecant. Add the Sec. of the H. A. or T. the Tangent of the Cor. Dec. and call the sum Tangent. Find the Sine of the True Alt. and the Sine of the first sum, or Tangent, and add the three logs for second sum of logs.

The sum of the first two logs or Tang. gives the first quantity and is set down as Ø″. Find the Cosine of the second sum of the three logs (Cosecant, Sine and Sine) and mark it Ø′. They are added or subtracted like Zenith Distance and Declination in the Meridian Altitude problem for Lat. In fact, the terms take the places of these quantities. If both are named alike—Add, if unlike—Substract. The answer will be the Latitude. Knowing your near-Latitude, there will be no trouble in finding out if the two funny terms are to be added or subtracted to secure the Lat.

In taking out these quantities from Bowditch Table 44, the smaller arc is used on the page.

EXAMPLES—A. M. at Ship, Lat. by D. R. 44° 52′ N. True Altitude found at this C. T. 20h. 23m. 38s. Long. in Time 3h. 02m. 56s. W. Find the L. M. T. Ans. 17h. 20m. 42s.

True Altitude of the star Procyon 50° 04′ 11″ bearing south. M. S. R. A. 13h. 45m. 1s. with corrections for G. D. Star's R. A. is 7h. 35m. 00s. Give the L. S. T. and H. A. Ans. L. S. T. 7h. 5m. 43s. subtracted from the star's R. A. gives Hour Angle.

Turn the H. A. into Arc, equals, 7° 19′ 15″ called T. Dec. of star 5° 26′ 18″. Now find the Sec. of H. A. or T. the Tang. of Dec. and add them. Call sum Tang. Find the Cosecant of the Dec. Sine of the Alt. and Sine of the first sum of logs. Add them and find the Cosine of this sum of second sum of logs. The Tang. of the first sum of logs gives term Ø″ in degrees, minutes and seconds of Arc. The Cosine of second sum of logs gives term Ø′ in Arc. Add or subtract them as per rules. In this case they are added.

Ans. Sum of first logs, 8.98220. Sum of second logs, 9.88823. Tang. of first sum of logs, Ø″ 5° 28′ 58″ N. Cosine of second sum of logs, Ø′ 39°22′ 03″ N. Lat. 44° 51′ 01″ N.

As the star was observed to the south, the Z. D. would be marked N. and the Dec. of the star is N., so the other term is marked N. Add when of like names and subtract when of different, gives Lat.

EXAMPLE—Star Sygni was observed off the Meridian with H. A. of 0h. 22m. 09s. True Alt. 54° 59′ 30″ N. Dec. of Star 44° 59′ 00″ N. Find the Lat. by the above method.
Ans. 10° 18′ 00″ N. Lat. the H. A.=5° 32′ 15″.

RULES—In using the stars, you must turn the L. M. T. into L. S. T. by rules given in book. Apply the star's Right Ascension to this L. S. T. to get the Hour Angle. This is turned into Arc as explained.

This problem may be worked by the Bowditch Table 26-27 as the time is not over those tables. H. A. 22m. 09s. and Lat. by D. R. of 10° 15′ 00″ N. gives a correction to the Altitude of 19′ 39″ to be added by the Ex. Meridian problem. Subtract 7′ 10″ from Alt. given, if you wish to try it.

EXAMPLE—H. A. 5° 12′ 01″ turned into Arc, Dec. 26° 15′ 06″ S. True Alt. 13° 12′ 00″ S. Give the Latitude. Ans. 50° 24′ 43″ N. using the Single Altitude and Time formula as above.

EXAMPLE—Watch set to correct time and observation taken for Latitude by the Ø″ Ø′ problem. Watch Time 2h. 56m. 48s. P. M. Long. 75° 16′ 30″ W. Eq. T. 11m. 11s. minus to M. T.

Cor. Dec. of the Sun, 5° 15′ 24″ S. True Alt. 31° 01′ 00″ S. Give the Lat.

Ans. As the Declination is over 3° the Lat. may be found by the Single Altitude and Time problem. The time before or after noon should not be over three hours for this problem. Lat. 39° 52′ 10″ N. Ø″ gives 6° 59′ 30″ N. Ø′ gives 46° 51′ 40″ S.

EXAMPLE—Observation of the Sun's L. L. May 28th gave Obs. Alt. 26° 40′ 20″ N. H. E. 15 ft. I. E. 20″ minus. Observation was taken in Long. 60° W. about 1h. and 15m. before noon. Cor. Dec. 14° 17′ N. Time by Chronometer at sight is 2h. 17m. 02s. Eq. T. plus to M. T. is 2m. 58s. Give the Latitude by the same problem as above.

Ans. As it is A. M. the G. D. must be found to get the Dec. and Eq. T. In the problem they are given corrected. Find the Time before Noon by applying the Eq. T. to C. T. and then subtracting the Long. in time to secure the L. A. T. gives May 27d. 22h. 20m. 00s. Subtract from 24 hrs. to get time from noon. Equals 1h. 40m. Turn this into Arc for the problem as before. Sum of first logs 9.44856. Sum of the second logs 9.69432. Indexes of logs having ten are dropped. If index is 11, drop 10 and hold 1.

Ø″ gives 15° 21′ 24″ S. Ø′ gives 60° 21′ 00″ N. Lat. 44° 39′ 36″ S.

THE WATCH AS A CHRONOMETER

Using the ordinary watch as a Chronometer, it must have tabs kept on it every few days to make the problems come correct when Time is used. You may set the watch to Greenwich Mean Time and call it your Chronometer, but you may have the use of the watch for Local Time, by knowing the Longitude you are taking sights in and applying it to what the watch says when it shows your Civil Time, instead of setting the G. T.

Few watches run with an even rate each day. That is the reason you should find out the error every few days. If you have a fine timepiece and find out the rate it is losing or gaining, you will be able to correct the time when sights are wanted by the Accumulated Rate, the Daily Rate. Say that watch was timed on April 10th at Noon by wireless, local nautical instrument dealer, or from a Chronometer. Again, you timed her after ten days and found she was ten seconds slow or fast. This would be the Accumulated Rate and the Daily Rate would be one second gain or loss each day. With this dope, you could expect to do fairly well with your Longitude Sights or any others that might be wanted for practice. Better keep tabs on her just the same and not trust to that Daily Rate.

On May 2nd your watch said 2h. 18m. 00s. P. M. Your Long. West is 72° 40′ 15″. What is the G. M. T.?

Ans. As you are West of G. the G. time would be after your time by W. T. plus Long. turned into Time. Long. equals 4h. 50m. 41s. plus Watch, equals G. M. T. May 2nd 7h. 08m. 41s. or Chronometer T.

Now suppose it was May 2nd 2h. 18m. 00s. A. M. by your watch and you wanted to know the G. M. T. or Chronometer T., which is just the same?

Ans. Add 12 hrs. to your W. T. and name the date one day back. Gives us May 1d. 14h. 18m. 00s. and the Long. in Time added gives us the G. M. T. May 1d. 19h. 08m. 41s., but expressed in the Astronomical form of time.

WHY? Ans. Your W. T. is surely 2-18 A. M. May 2nd. G. T. is after your time by the Long. in T. Adding the Long. we would have May 2d 7h. 08m. 41s. A. M. Civil Time at Greenwich. You do not express G. T. as Civil Time. You want the time there in the Astronomical form of time. You must add 12 hours to Civil Time when a problem is given in A. M. as the Astronomical Time commences at Noon each 24 hours. This would make our G. M. T. expressed in A. T. as given. Astronomical Day commences 12 hours back of the Civil Day and runs for 24 hours straight.

WATCH TIME INTO APPARENT TIME. Now let us find from our W. T. the A. T., so that we may know when to take the Noon Lat. You have a sextant, a pan of oil for an Artificial Horizon, and your watch with its rate, and are ready for a sight from your roof or window. You must know the instant the Sun's center has crossed your Meridian or True South point of the compass, if you are in the Northern Hemisphere.

May 2nd find the Equation of Time to apply to the W. T. to secure Apparent Time at Noon. Ans. Your Long. is 90° W., we will say. This gives you the number of hours to correct the Eq. T. by. 90° equal 6 hours. The Eq. T. is corrected for that number of hours from the difference given for each hour in the Nautical Almanac. Now you have the Cor. Eq. of T. and the sign tells you if it is to be added to M. T. or subtracted.

Set down 11h. 59m. 60s. the same as 12 hours or Noon, subtract or add your rate of watch and apply the Eq. of Time. This gives you the Apparent Time for Noon and the Sun's centre will be on your Meridian at that time. Get his Altitude and watch for a little while, say two minutes, to find out if he is dipping or going down towards the West. This is not always necessary, but it gives you confidence for other sights and times by your watch.

MEAN TIME—To get mean time from an Apparent Time quantity, you apply the signs given in the N. A. just the reverse. If you have applied the Eq. T. to your W. T. for A. T., take the same off or on (opposite of sign) and you have M. T.

LOCAL SIDEREAL TIME BY THE WATCH—You wish to find L. S. T. by W. T. so that you may know which side of the Meridian the stars are on. Say W. T. May 2nd P. M. was 8h. 40m. and your Long. West was 90° or 6 hrs. in time. Get the M. T. G. (mean time at Greenwich) so that you may pick out the quantities from the N. A. to turn W. T. into L. S. T.

M. T. G. May 2d, 14h. 40m. 00s. Look up the M. S. R. A. ("Right Ascension of the Mean Sun at Greenwich Mean Noon") or Sidereal Time, correct it for the number of hours after Noon at G. from the M. T. G. and add the quantity to your C. W. T. (correct watch time) and you have L. S. T. The M. S. R. A. must always be taken out for G. D. and corrected for number of hours after that start of the day or noon.

May 2nd, and 14h. 40m. after, gives us M. S. R. A. with cor. 2h. 41m. 44s. to be added to W. T. The L. S. T. corresponding to your watch time is 11h. 21m. 44s.

GREENWICH SIDEREAL TIME FROM WATCH TIME—This requires little thinking, as the rules are the same. If you know the G. M. T., all there is to it, find the M. S. R. A. for the date and correct it for the number of hours past noon at G. Add the quantity and you have G. S. T.

CORRECTING M. S. R. A.—The small table under "Right Ascension of the Mean Sun at Greenwich Mean Noon" is for that purpose, and may be taken out at sight. Use the Hours of your G. D. and chase across line until you find the minutes. This correction is to be added.

Declination and equation of time are corrected by the G. D., but their differences for each hour are found in their proper places alongside of the terms.

Be sure to apply all corrections in accordance with the way the quantity is going. If increasing, add. If decreasing, subtract in West Long. and the opposite in East Long.

EXAMPLES—W. T. 8h. 30m. A. M. Long. 60° W. gives C. T. 12h. 30m. 00s.
W. T. 3h. 40m. 00s. A. M. Long 75° W. gives G. T. 8h. 40m. 00s. M. T.
Ast. T. would be G. D. 20h. 40m. 00s.

W. T. 11h. 40m. 20s. A. M. slow 10m. Eq. T. 12m. 20s. plus to M. T. Gives Apt. T. 12h. 02m. 40s. P. M.

Eq. T. 8m. 32s. minus to M. T. Watch says Noon. Gives Apt. T. 11h. 51m. 28s. A. M.

W. T. 3h. 00m. P. M. took sight at that instant, watch fast 9m. on noon of three days back, and gaining 40s. daily, gives us Cor. W. T. of 2h. 48m. 50s. P. M.

W. T. June 4th 9h. 20m. 00s. P. M. Watch fast 12m. M. S. R. A. with corrections for Long. 4h. 50m. 24s. gives L. S. T. 13h. 58m. 24s.

W. T. 4h. 20m. 00s. P. M. Long, you are in, 60° E. gives G. M. T. 0h. 20m. 00s., expressed in Ast. form of T. Civil Time would be 12h. 20m. 00s. P. M., or Twelve-twenty P. M., while at your home in Long. 60° E. it would be Four-twenty P. M.

W. T. July 5d. 10h. 20m. 04s. A. M. Long. 75° W. gives G. M. T. July 5d. 5h. 20m. 04s. P. M.

The same times expressed in Ast. T. gives W. T. July 4d. 22h. 20m. 04s.
G. T. July 4d. 17h. 20m. 04s. called Greenwich Date.

CORRECTING COURSES

TRUE COURSE equals Leeway—Left, Deviation, West, Variation West from COMPASS COURSE.

Just the OPPOSITE when we wish to know the Compass Course from the True Course.

If the Leeway is Right, Deviation, East and Variation East, to get True Course apply all to right of Compass Course and opposite for Compass Course from True Course.

USING 360° CARD for correction of course—

Better use the 360° compass so that you will not get mixed when changing courses. It will be noticed that all change of degrees, minutes and seconds from North around by the way of East is increasing to 360° or North, and just the opposite when going the other way. Some navigators use Quadrants, starting from North to East and 90°, and from East to South 90° to 0° then from 0° or South to West or 90° and thence to North again from 90° to 0°.

You must remember the Quadrants when securing the True Courses, as they must be used when working the Traverse Form to get the Diff. Lat. and Departure.

QUESTIONS AND ANSWERS ON COURSES

Give the True Course—Compass Course South, Leeway 2¾ pts. L., Dev. 14° 4′ E., Var. 16° 52′ E. Ans. True C. 179° 59′ 45″, Quadrant S. E.

Compass C. E. ¾ S. L. W. 1¾ pts. L., Dev. 15° E., Var. 42° E. Ans. True C. 135° 45′, Quad. S. E.

Com. C. W. N. W. Lee. W. 3 pts. L., Dev. 18° 30′ W., Var. 42° E. Ans. True C. 282° 15′, Quad. N W.

Com. C. N. E. x E. Lee W. ½ pt. R., Dev. 19° E., Var. 14° E. Ans. True C. 94° 52′ 30″, Quad. S. E.

Com. C. N. E., Dev. 1 pt. E., Var. 1 pt. E. Ans. True C. 67° 30′, Quad. N. E.

Com. C. S. W., Dev. 1 pt. W., Var. 1 pt. W. Ans. True C. 202° 30′, Quad. S. W.

Com. C. E. S. E. ¼ E., Lee. W. 11° 15′ L. Dev. 11° 15′ W., Var. 5° 37′ 30″ E. Ans. True C. 92° 48′ 45″, Quad. S. E.

Com. C. W. x N. Lee. W. 1 pt. L., Dev. ½ pt. E., Var. ½ E. Ans. True C. 281° 15′, Quad. N. W.

Com. C. E. N. E. ¼ E. Lee. W. ¾ pt., Dev. ½ pt. E., Var. 9° W. Ans. True C. 58° 30′ 05″, Quad. N. E.

Com. C. N. ¼ W. Lee. W. ¼ pt. L., Dev. ¼ pt. W., Var. 11° 15′ W. Ans. True C. 340° 18′ 45″, Quad. N. W.

Com. C. N. E. x N., Dev. ½ pt. W., Var. ¼ pt. E. Ans. 30° 56′ 15″, Quad. N. E.

Com. C. W. S. W., Dev. ½ pt. E., Var. ¾ pt. W. Ans. True C. 244° 41′ 15″, Quad. S. W.

GIVE THE COMPASS COURSE

True C. 132° 11′ 15″, Dev. ¼ pt. E., Var. ½ pt. E. Ans. S. E. x E.
True C. 264° 22′ 30″, Dev. ½ pt. E., Var. ¾ pt. E. Ans. W. S. W. ¾ W.
True C. 180°, Dev. 11° 15′ E., Var. 11° 15′ E. Ans. S. S. E.
True C. 281° 15′, Dev. ½ pt. W., Var. 1 pt. W. Ans. N. W. x W. ½ W.
True C. 360, Dev. 1 pt. E., Var. 1 pt. W. Ans. North.
True C. 258° 45′, Dev. ½ E., Var. 1½ pts. W. Ans. West.
True C. 168° 45′, Dev. ¾ E., Var. ¼ W. Ans. S. x E. ½ E.

GIVE THE MAGNETIC COURSE

Compass C. South, Deviation ½ pt. E. Ans. S. ½ W.
Com. C. S. W. x S., Dev. ½ pt. E. Ans. S. W. ½ S.
Com. C. W. N. W., Dev. 2 pts. W. Ans. West.
Com. C. N. E., Dev. 1 pt. E. Ans. N. E. x E.
Com. C. W. ½ S., Dev. ¾ pt. E. Ans. W. ¼ N.

TIME AND CHANGES

Astronomical Time is secured from Mean Time A. M. by adding 12 hours and setting the day one back. What is Ast. T. of this Mean Time A. M.: June 5th, 4 hrs. 20 m.? Ans. June 4th, 16 hrs. 20 m.. For 6 hrs. 40 m. July 20th A. M.? Ans. 18 hrs. 40 m. For Mean Time June 4th P. M. 5 hrs. 15 m.? Ans. The same number of hours and minutes, but drop the P. M. When P. M. is given of a certain date, in M. T., it is also Astronomical Time, or the number of hours, minutes and seconds past the noon hour at Greenwich, of given day.

GREENWICH DATE: All problems in navigation must have a Greenwich Date known. Problems in Longitude, Latitude, Time Azimuth, Amplitudes, Sumner Method, Pole Star, Sunset and Sunrise, Declination, Equation of Time, St. Hilaire Method, must have a G. D.

EXAMPLES: Nov. 9th 5 hrs. 10 m. P. M. Apparent Time, Long. 32° 45′ W. is G. D. Nov. 9th 7 hrs. 21 m. Jan. 5th 6 hrs. 15 m. A. M. Mean Time, Long. 140° 30′ E. is G. D. Jan. 4th 8 hrs. 53 m. April 27th 5 hrs. 35 m. 45 s. A. M. Mean Time at ship, Long. 122° 13′ W. is G. D. April 27th 1 hr. 44 m. 37 s.

RULE: To ship's date A. M. add 12 hrs. and set the day one back. Add the Long. W. and if over 24 hrs. subtract 24 and give the date same date as ship's date. Remember Long. must be turned into time. If Long. is E. subtract Long. in time from Astronomical Time. If Long. is greater than Ast. T. add 24 hrs. and name date one back.

EQUATION OF TIME: This time turns Mean Time into Apparent Time. It is found in the Nautical Almanac for each day with Hourly Difference to be applied to get the corrected Equation of Time. The Almanac gives the signs to show if it is to be subtracted from Mean Time or the Reverse.

EXAMPLES: July 11th Eq. Time is —5 m. 12 s. at Greenwich. What would it be for a place that had Long. W. in time of 4 hrs.? Ans. —5 m. 13.5 s. Same date but Long. in time 12 hrs.? Ans. —5 m. 16.2 s.

Now for June 11th with Long. W. 5 hrs. and time at place 4 P. M.? Change would have to be taken out for number of hours of the Long. and the time at place, making 9 hrs. to apply to the H. D. of the Equation of Time to get the Correct Eq. T. Ans. + 0 m. 37.2 s.

Notice that the Eq. T. in July is marked minus and in June, plus. This means you add the Eq. T. to Mean Time for the June date and subtract it for the July date, to get Apparent Time. Of course, the rule works backward to get Mean Time from a given Apparent Time.

DECLINATION IS ALSO TIME: Give the Declination for Greenwich NOON March 20th. Ans. 0° 16′ 24″ S. For 16 hours later. Ans. 0° 0′ 36″ S. Now for 2 hours later still. Ans. 0° 1′ 24″ N. At these two later times, the sun has crossed the Equator from South Declination to North Declination. Give Dec. for June 21st at Greenwich Noon. Ans. N. or + 23° 27′. The sun has reached its highest Declination North and will now start to go South again. Give Dec. for June 23rd. Ans. N. 23° 26′ 36″. It can be seen at once the Dec. is decreasing now, although still named N. or +. Give the Dec. for September 23rd. Ans. N. 0° 2′ 54″. He is getting ready to cross the Line again into South Declination. Give the Dec. for 6 hours later. Ans. S. 0° 2′ 54″. Now he will travel South until he reaches Declination S. 23° 27′ 00″ which will be Dec. 22nd. Give the Declination for December 25th at NOON in Long. 75° W. Ans. S. 23° 24′ 00″. The Long. 75° equals 5 hours. This is the number of hours past NOON at Greenwich, so the H. D. must be changed for this quantity to get the Corrected Declination.

HOURLY DIFFERENCE: What would be the correction to Declination with 10 hours past Greenwich NOON, with H. D. 30″? Ans. 5′. For 8 hours and H. D. of 1′ 2″? Ans. 8′ 16″ to be added if the Dec. is increasing in W. Long. and to be subtracted if decreasing in W. Long. Just the opposite in E. Long. Suppose the correction of the H. D. was greater than the Declination? Ans. Subtract the Dec. from correction and give opposite name of Dec.

Dec. S. 0° 10′ 42″ H. D. 1′ correction for 12 hours equal 12′. The Dec. subtracted gives, Ans. N. 0° 1′ 18″.

SIDEREAL TIME: Commences from the Prime Celestial Meridian and any point on the surface of the earth starts its Sidereal Time from that point and runs around 24 hours.

Right Ascension is also Sidereal Time and commences from the Great Celestial Prime Meridian which is a fixed time each year when the Sun crosses the Equator in March. All Right Ascension is tabulated in the Nautical Almanac in hours, minutes and seconds of time each day of the year from this point. It can be seen at once that the Right Ascension is then more each day after March 23rd.

The difference between Sidereal Time and Right Ascension is that Sidereal Time of a star is a fixed time quantity, and does not have but a very small change each year. Local Sidereal Time changes each day.

LOCAL SIDEREAL TIME is secured by knowing local time, Long. of place, Mean Sun's Right Ascension.

RULE: To the Time at Place, add the M. S. R. A. with Correction for number of hours after Greenwich Noon. Gives Local Sidereal Time. L. S. T.

EXAMPLES: L. T. 8 P. M., M. S. R. A., 5 hrs. 13 m. 5 s. cor. for 13 hrs. plus 2 m. 8 s. Ans. L. S. T. 13 hrs. 15 m. 13 s. The 13 hrs. used for cor. was secured by knowing the Long. In this case 75° W. in time, or 5 hrs. added to local time gave the G. D.

L. Time 10.30 P. M. Long. 75° W. Give L. S. T. Ans. 15 hrs. 10 m. 9 s. This Sidereal Time corresponds with the Local Time given. Any Nautcial Almanac will give nearly the same answer, using date June 1st. Local Time is 2 A. M. Feb. 6th. Long. 75° W. Ans. 11 hrs. 4 m. 12 s. L. S. T. May 15th P. M. 75° W. Local Time is 8 o'clock. Give L. S. T. Ans. 11 hrs. 33 m. 39 s. L. S. T. Aug. 16th 8.45 P. M. Long. 75° W. gives L. S. T. 18 hrs. 25 m. 26 s. June 2nd 6 P. M. Long. 60° E. Give L. S. T. Ans. 10 hrs. 41 m. 52 s. L. S. T. June 2nd 2 P. M. Long. 60° E. Give L. S. T. Ans. 6 hrs. 41 m. 12 s. In this case you must find the G. D. and take out the M. S. R. A. for it and correction for number of hours after the Astronomical Date. The Mean Time at Greenwich would be June 1st 10 A. M., or 2 hours before the commencement of the next Astronomical Day. The correction may be taken out for 2 hours before this day and subtracted from the M. S. R. A. of date June 2nd. June 2nd 2 A. M. Long. 60° E. Give L. S. T. Ans. 18 hrs. 39 m. 15s. June 2nd 2 P. M. Long. 95° E. Give the L. S. T. Ans. 6 hrs. 40 m. 56 s. Here the Long. in time is greater than the Local Time, so add 24 hrs. to L. T. and subtract, and give the G. D. one back. Take out the M. S. R. A. for this date and correct for the number of hours after NOON at Greenwich for L. S. T.

GREENWICH SIDEREAL TIME: To secure this time, you add the M. S. R. A. to the Chronometer time and add the correction for the number of hours after NOON at Greenwich.

EXAMPLES: C. T. 6 hrs. 58 m. 58 s. M. S. R. A. is 1 h. 34 m. 11.3 s. Give G. S. T. Ans. 8 hrs. 34 m. 18.3 s. Hunt up the change for the C. T. to be added to C. T. and M. S. R. A. for G. S. T.

C. T. 19 hrs. 56 m. 02 s. M. S. R. A. is 1 hr. 34 m. 11.5 s. Give G. S. T. Hunt up the correction for the C. T. in Bowditch Table No. 9.

Ans. 21 h. 33 m. 30 s. G. S. T.

ARC INTO TIME AND REVERSE

This may be done by consulting Table No. 7 of Bowditch. If you wish to figure out the quantities, you may do so in several ways.

RULES:

1° equals 4m. or the 15th part of 60m.
1′ equals 4s. or the 15th part of 60s.
1″ equals 4t. or the 15th part of 60t.
t. is the name given to the sixtieth part of one second.

20° 40′ 18″ turn into Time. Multiply the seconds by 4 and divide by 60. gives us 72 ÷ 60 = 1 and 12t. The 12t. is also 2 tenths of a second and may be set down that way, but when you cannot get exact tenths, set down the t. 40′ x by 4 and add the one second from the other division and again divide by 60, gives us 41s. and 2 to be added when we multiply the degrees. 20° x by 4 and add the 2 and then divide by 60, gives us 1h. 22m.

Answer.—1h. 22m. 41s. 12t. (or .2).

ANOTHER WAY—Divide every quantity by 15 and what is left over from each, multiply by 4.

20° ÷ 15 = 1h. 5 over × 4 = 20m.
40′ ÷ 15 = 2m. 10 over × 4 = 40s.
18″ ÷ 15 = 1s. 3 over × 4 = 12t.
Add them up and we have 1h. 22m. 41s. 12t.

EXAMPLES:

130° 19′ 00″	equals	8h. 41m. 16s.
0° 41′ .7	equals	0h. 2m. 46.8s.
89° 16′ 00″	equals	5h. 57m. 04s.
96° 10′ 45″	equals	6h. 24m. 43s.
178° 49′ 45″	equals	11h. 55m. 19s.
2° 18′ 12″	equals	0h. 09m. 12s.8

0°	26′ 08″	equals	0h. 01m. 47s.2
156°	52′ 00″	equals	10h. 27m. 28s.
137°	27′ 00″	equals	9h. 9m. 48s.
12°	40′ 45″	equals	0h. 50m. 43s.
49°	40′ 20″	equals	3h. 16m. 17.33s.
51°	10′ 12″	equals	3h. 24m. 40.8s.

TIME INTO ARC

Consult Bowditch, Table No. 7, or calculate the quantities.

RULES: 4m. equal 1° and 4s. equal 1′ and 4t. equal 1″.

1h. 22m. 41s. 12t. turned into Arc. Multiply the hours by 15 and call them degrees; divide the minutes by 4 and set them under the degrees and what is left over multiply by 15 and set down as minutes of Arc. Divide the seconds by 4 and place in the minutes of Arc and what is left over multiply by 15 and set down as seconds of Arc. Divide the t. by 4 and set down under seconds of Arc.

CAUTION—should there be some left over in the ts. you multiply by 15 and call it hundreds of a seconds of Arc. If we had 15t. instead of 12t. we would divide the t. by 4, giving us 3″ and 3t. left over or .45″.
Answer—20° 40′ 18″.

EXAMPLES:

1h.	13m. 52s.	equals	18° 28′ 00″
0h.	21m. 30.9s.	equals	5° 22′ 43.5″
0h.	01m. 52s.	equals	0° 28′ 00″
5h.	00m. 51s.	equals	75° 12′ 45″
0h.	03m. 52s.	equals	0° 58′ 00″
9h.	49m. 38s.	equals	147° 24′ 30″
11h.	41m. 6.66s.	equals	175° 16′ 40″
11h.	59m. 57s.	equals	179° 59′ 15″

LONGITUDE

March 22nd, 1917, A. M.

EXAMPLES—Watch Time 8h. 46m. 39s. Fast 2m. 37s. Long. by D. R. 75°, or 5h. W. Eq. T. minus 7m. 4s. to M. T. Required the G. A. T. Ans. March 22d. 1h. 36m. 58s. G. D.

Obs. Alt. from Art. Horz. 57° 59′ 00″ S. I. E. minus 35″ correction to Alt. 14′ 25″ plus. Dec. corrected 0° 32′ 0″ N. Lat. 39° 59′ N. Give Polar Dist. and Long., using the above G. D. Ans. P. D. 89° 28′. Hour Angle 8h. 35m. 37s., taken from A. M. column of Bowditch. Long. 75° 17′ 45″ W. Apply I. E. to Obs. Alt. divide by 2 when using Ast. Horz.

Greenwich Apparent Time 5h. 48m. 58s. P. M. at ship. True Alt. 20° 34′ S. True Dec. 23° 14′ 42″ N. Lat. by D. R. 24° 12′ N. Give Long. Ans. 10° 18′ 30″ W.

P. M. at ship. G. A. T. 7h. 50m. 02s. True Alt. 30° 30′ 28″, Lat. 39° 58′ N. P. D. 95° 15′ 24″. Give the Sine for the Hour Angle. Ans. 9.55548, or 2h. 48m. 28s. L. A. T.

Give the Long. from the above date. Ans. Long. 75° 23′ 30″ W.

Long. in Time equals 4h. 19m. 43s. Give the Long. Ans. 64° 55′ 45″ W.

Hour Angle of Sine is 2h. 16m. 49s. Give the Sine. Ans. 9.46847.

G. A. T. is 6h. 36m. 32s. L. A. T. equals Sine 9.46847. Give the Long. Ans. 64° 55′ 45″ W.

P. M. at ship. Lat. by D. R. 30° 30′ N. Dec. corrected, 18° 5′ 42″ N. G. A. T. 3h. 32m. 49s. True Alt. 40° 20′. Give the A. T. at Ship and the Long. Ans. Ship's A. T. 3h. 33m. 10s. Long. 0° 5′ 15″ E.

P. M. on Roof Garden had G. S. T. 12h. 00m. 36s. Alt. corrected of star Rigel was 44° 58′ S. Lat. 39° 58′ N. Dec. of star 8° 17′ 48″ S. Give Long. Ans. 76° 47′ 00″ W.

March 20th A. M. at ship. Lat. 0° 0′ 0″. True Alt. 29° 0′ 58″. C. T. 20d. 3h. 32m. 46s. Being P. M. at Greenwich M. T. Cor. Dec. 0° 0′ 33″ N. Eq. T. plus to Apparent Time, 7m. 29s. Give Sine of ½ sum of logs. Hour Angle, Long. in Time and Long. Ans. Sine 9.70537. H. A. 7h. 56m. 04s. Long. in T. 7h. 29m. 13s. Long. equals 112° 18′ 15″ W. A. T. at S. March 19d. 19h. 56m. 4s.

Sept. 23rd A. M. at ship. Lat. 0° 0′ 0″. Obs. Alt. Sun's L. L. 45° 21′ 10″ index error minus 1′ 7″, H. E. 17 ft. Greenwich Date in Mean Time Sept. 22d 20h. 54m. 26s. Eq. T. minus to Apparent T. 7m. 39s, Cor. Dec. 0° 7′ 10″ S. Give the A. T. S., the Hour Angle, the G. A. T., the Long. in T., the Long. Ans. A. T. S. 22d 21h. 2m. 5s. H. A. 9h. 2m. 5s. G. A. T. Sept. 22d 21h. 02m. 05s. Long. in Time 0° 0′ 0″. Long. is Prime Meridian of Greenwich, which is 0°. Eq. T. is added to G. M. T. to get G. A. T.

Dec. 25th A. M. at ship. Lat. 9° 59′ S. True Alt. 10° 42′ 51″. G. M. T. Dec. 24d. 17h. 42m. 57s. Eq. T. 15s. minus to M. T. Correct Dec. 23° 24′ 36″ S. Work up the Long. problem. Ans. G. A. T. 24d. 17h. 42m. 42s. Sine of log 9.81938 gives H. A. 6h. 29m. 43s. Long. in T. 47m. 1s. Long. 11° 45′ 15″ E.

June 15th A. M. at ship. Lat. at Noon 11° 46′ N. Run since sight to Noon S. W. ¾ W. 42 miles. Obs. Alt. for Long. Sun's L. L. 39° 39′ 40″, I. E. plus 20″ H. E. 17 ft. C. T. 14d. 17h. 59m. 30s., being 5h. 59m. 30s. A. M. at G., which was slow 5m. 56.3s. for M. T. G. April 20th, and on May 12th was 2m. 29.5s. slow for Mean Noon at Greenwich. Give the Long. at Noon and at Sight. Ans. Interval 22d., rate 9.4s. gaining, interval 33d. 18h., accumulated rate, minus 5m. 17.2s. G. D. June 14d. 17h. 56m. 42s. Eq. T. minus to M. T. 10s. Cor. Dec. 23° 19′ 22″ N. Sine of log. 9.63896 gives H. A. 8h. 33m. 28s. A. T. at S. June 14d. 20h. 33m. 28s. Long. at Sight 39° 14′ E. Long. at Noon 38° 39′ 33″ E. Diff. Long. for run 34′ 27″ W.

Sept. 13th about 8.30 P. M. at ship, Lat. 33° 55′ S. Long. by D. R. 66° E. C. T. 4h. 2m. 56s. On June 29th, at Greenwich M. Noon, the C. was 4m. 1s. slow on G. M. T. and losing 2.4s. daily. True Alt. 26° 28′ 11″ East of the Meridian of star Markab. Star's Dec. 14° 39′ 23″ N. Star's R. A. 22h. 59m. 41s. M. S. R. A. 11h. 30m. 41s. with correction. Give the Long. Ans. S. T. G. 15h. 40m. 41s. S. T. S. 20h. 7m. 37s. H. A. 2h. 52m. 04s. Long. 66° 44′ 00″ E. H. A. is subtracted from star's R. A. for S. T. at S., as the star was East when observed.

Long. D. R. 75° W.

March 29th A. M. on Roof Garden. Watch Times 9h. 43m. 47s., 9h. 50m. 45s. Watch fast 2m. 38s. Obs. Alts. Sun's L. L. by Art. Hoz. 81° 48′ 30″, 83° 54′ 30″. Index Error, 22′ 30″ minus. Semidiameter, plus 16′ 03″. Parallax and Refraction minus 59″. Corrected Declination, 3° 16′ 50″ N. Cor. Eq. T. 4m. 55s. minus. Give the G. D. and the P. D. Ans. A. T. G. 29d. 2h. 39m. 43s. P. D. 86° 43′ 10″. The times of sights are to be added and then mean taken, same with the Obs. Alts. Lat. of Roof Garden 39° 59′ 00″ N. Give the Hour Angle for the half sum of the logs. Ans. Hour Angle or Apparent Time at Roof Garden from half sum of logs, 9h. 39m. 18s. This time must be expressed in Astronomical form. Apparent Time at Garden 28d. 21h. 39m. 18s. Notice that 12 hours have been added, as the sight is A. M. Long. in Time is 5h. 00m. 25s. Long. is 75° 6′ 15″ W.

QUESTIONS—How did we find the Chronometer Time and G. D. from our Watch Time? Ans. By adding the Long. 75° 0′ W. in TIME to the mean of the times after the "fast" was taken off. Then by adding 12 hrs. to turn the time into Astronomical T. we had the date one day back. This gave us March 28d. 26h. 44m. 38s. for date. Subtract 24 hours and name the day one ahead gives us, G. D. March 29d. 2h. 44m. 38s. After Eq. T. is taken off, to correct the Declination and to apply the A. T. at Garden for the Long. The Eq. of T. was subtracted from the G. M. T. to turn it into A. T.

GETTING LONGITUDE BY STARS OR PLANETS

RULES: Turn the C. T. into G. S. T. by adding the M. S. R. A. and the Correction for the number of hours after Noon at G. This gives us G. S. T. Work the Long. problem just the same as the Sun, but there is no change to the star's Dec. Get the Hour Angle from the P. M. COLUMN and add or subtract the star's R. A. to it. This gives us L. S. T. Now apply L. S. T. with the G. S. T. and subtract one from the other. If the G. S. T. is best the Long. is West and if Least, the Long. is East.

ADDING OR SUBTRACTING THE STAR'S RIGHT ASCENSION TO, OR FROM H. A.: If the star is west of the Meridian, the Star's R. A. is ADDED and if East of the Meridian, the Star's R. A. is SUBTRACTED. MEANING—SUBTRACT ONE FROM THE OTHER.

EXAMPLES: C. T. 27d. 6h. 51m. 24s. M. S. R. A. with correction is 20m. 53s. Added, gives G. S. T. True Alt. is 40° 15′ 47″. Lat. is 22° N. Star, Regulus, Declination is 12° 27′ 43″ N. Star's R. A. is 10h. 2m. 59s. Give the Long. Ans. Long. 94° 01′ 00″ E. L. S. T. is 27d. 13h. 28m. 21s. The Date of the examples is March 28th. A. M. so the L. S. T. is set back one day. Hour Angle is W.

April 20th P. M. at Ship. The C. T. Ap. 20d. 12h. 28m. 54s. M. S. R. A. with correction, 1h. 56m. 26s. Give the G. S. T. Star's Declination 19° 42′ 29″ N. and its R. A. is 14h. 11m. 04s. Lat. by D. R. is 44° N. True Alt. by observation of the star, 37° 8′ 7″. Give the Sine of half the sum of the logs. for the H. A. Ans. Sine of 9.67823 equals H. A. 3h. 47m. 45s. East. Give the Long. Ans. Long. 60° 30′ 15″ W.

LONGITUDE AND RULES

The Long. problem or Time Sight is one of the most used at sea to secure the Longitude. The sextant, Chronometer and Nautical Almanac are required to work this problem for the first part. The second part of the example requires the Bowditch Table No. 44.

RULES—Secure the Obs. Alt. and take the instant of time at contact of the Sun's Lower Limb with the Sea Horizon or Art. Hor. The time must be correct and snapped at the very instant the sight is made. Here is the way it is done by two men:

The stop watch has been set to the Chronometer time or its difference noted, but the stop is allowed to start exactly on the minute and continues to run until the sight-taker calls "Time." Another man stops the stop hand and at once places the exact time on a piece of paper or book for the purpose.

If the observers wish to use the watch while taking the sight, it may be done, but requires a little practice if there is a sea on. By holding the watch in the left hand and working the Arm of the sextant, he may stop the stop-hand instantly, and note the time before taking the reading of the sextant for the Arc, or number of degrees and minutes. The Time and Arc are set down and the next sight taken, should there be a doubt of the first one. Many of the navigators take a set of sights and then take the mean of them to allow for errors of contact of the Sun with the Horizon.

WORKING THE PROBLEM FOR LONGITUDE

After the Obs. Alt. has been secured and the Time noted, the Altitude is corrected from Table 46 Bowditch. Of course, the Index Error of the instrument must be allowed also. We have then the True Altitude. The Declination is looked up from the Almanac and corrected for the time past Noon at Greenwich for the G. D. If the Dec. and Lat. are of the same name, the Declination and 90° are subtracted for the Polar Distance. If of different names, 90° added to the Declination gives the Polar Distance.

Set down the Corrected Chronometer Time and change it into G. A. T. by applying the Equation of Time, secured from the Nautical Almanac.

Now set down the logs. Altitude, the Latitude by D. R., the Polar Distance and add them up. Then divide the sum by two and call it Half Sum. Now subtract the Altitude from the Half Sum and call it the Remainder.

TAKING OUT THE LOGS. The logs are now taken out of Table 44 Bowditch for the following: Secant of the Latitude, Cosecant of the Polar Distance, Cosine of the Half Sum and Sine of the Remainder. These logs. are then added and divided by two. Get the Sine of this sum (after dividing by 2) from the tables for the Hour Angle. This is taken from Table 44 Bowditch in the P. M. Column if P. M. at ship or in the A. M. Column if A. M. at ship.

This is the Correct Apparent Time at Ship, at instant the sight was taken. To know the Long. at this same instant, we must apply the Local Apparent Time with the Greenwich Apparent Time. If the G. A. T. is greater than the ship time, the difference will be the Long. West, after the hours, minutes and seconds have been turned into Arc.

EXAMPLE: Feb. 3rd, 1917, A. M., at ship. Chronometer Time is Feb. 2d, 22 hrs. 17 m. 16 s. Obs. Alt. Sun's L. L. is 19° 49′ 50″ S. Corrected Dec. is 16° 37′ 54″ S. Lat. is between 48° 10′ N. and 48° 40′ N. Equation of Time corrected is 13 m. 57 s. minus. Height of eye 20 feet. Work two Long. problems with the Lats. given and show Line of Position on chart. Ans. Lat. 48° 10′ N. used, gave Long. 0° 29′ 45″ W. Lat. 48° 40′ N. used to work problem gave Long. 0° 49′ 45″ E.

After the first sight was taken a RUN was made and another sight taken. The Run is E. X. N. ½ N. 39 miles. Then the Obs. Alt. was 10° 53′ 30″ S. Chronometer Time is Feb. 3d, 3 hrs. 37 m. 11 s. P. M. at ship, remember now, H. E. 20 ft. Corrected Eq. T. is 13 m. 59 s. minus. Dec. corrected is 16° 33′ 12″ S. Use the same assumed Lats. as in other problem and give two Longitudes to show another Line of Position. Set off the Run from First Line of Position and show crossing of the Lines for location of the ship at second sight.

Ans. Lat. 48° 10′ N. gave Long. 0° 5′ 15″ E. and Lat. 48° 40′ N. gave Long. 0° 34′ 15″ W. The crossing of the lines show location of the ship Lat. 48° 14′ N. Long. 0° 1′ 0″ E.

SUMNER LINES, LINES OF POSITION AND AZIMUTH

There are several ways to plot on the chart Sumner Lines, or Lines of Position, to show the calculated position of the ship when at sea. Charts are made especially for this work (see advertisement in this book) and with the Latitude and Longitude of an approximate location set down on the chart as a dot; the Azimuth at time of sight taken, from the Azimuth Tables, may be run from the compass rose of the chart to the dot. This gives the True Bearing of the Sun, Star, Planet or Moon at the Apparent Time of taking the sight.

THE POSITION LINE may now be laid off at right angles with the Azimuth Line, crossing the dot, or position by Lat. and Long. We have then a drawing of the True Bearing of the Sun at the sight-time and the First P. Line. We are somewhere on that line, and should our Lat. be known correctly, and the Long. approximately, it may be claimed we are within a few miles of our calculated position, but on the First L. of Position.

No single sight or Sumner Line will give an absolutely fixed position, as we must wait for a change in the bearing of the Sun or other bodies before we take another sight, either for Lat. or Long, and then plotting the Second L. of Position. If the ship should hold her location during this lapse of time, from first bearing of the Sun until the second has been taken, there will be a crossing of the Sumner, or Position Lines, which will show very nearly the spot the ship is on.

CHANGING THE POSITION: Should the ship sail on a certain course after taking the first sight, which is the case at sea, then the First Line of Position must be brought up to cross the Second Line of Position to show the Position Arrived At. This is done by taking the parallel rulers and bringing up the First P. Line to the end of the RUN on a certain course. The RUN is measured in nautical miles corresponding to the mile in the Latitude the ship is in. The Course is laid off that has been sailed from the First P. Line, and where the Brought Up Line crosses the Second L. of Position, at the end of the RUN, is the location of the vessel as near as navigators may calculate.

After this work has been plotted on the chart, it is an easy matter to take with the dividers the Lat. and Long. of the Fixed Position by the crossing of the lines. From this new position, draw another line parallel with the Course Line to the First Position Line. This will show the location of the ship when the first sight was taken. This is called the Return Line. Up-to-date navigators plot these lines for all runs, changes of location, and keep tabs on their position very carefully by this method.

METHODS USED TO SECURE POSITION LINES.

The latitude at Noon has been secured by sextant and Meridian Altitude problem. We have used the Longitude to this NOON Position, by Dead Reckoning from the A. M. sight. We have now Lat. by sight and Long. by D. R. This is plotted on our Sumner chart or any chart that is used best for this work, and find we are in, say—Lat. 32° N. Long. 68° W. and the Time is Noon. This would make our Azimuth, or True Bearing of the Sun nearly 180° or South. With the Azimuth Line from the Latitude secured by sight and Long. by D. R. we draw at right angles, the First P. Line, which is seen to be the Parallel of Lat. 32° N. From this position we run course (True) North West, for 60 miles, then a sight is taken for Long. and the Lat. is used to work up the problem that has been calculated by the D. R. Now we have another position at four hours later, we will say, from the first sight. This "spot" is marked on the chart, the Azimuth Line set off on its proper angle from the "spot" and then the Second Line of Positions is drawn at right angles to the Azimuth Line crossing the "spot." Bring up the First Position Line to the end of the Run and draw line until it crossed the Second Line of Position. This gives us the spot we are on at the second sight.

The Azimuth from the tables at time of sight is generally used to get the Lines of Position, as it is very quickly done that way. It may be done by assuming another Lat. some thirty minutes either side of the supposed Lat. and working two Long. problems. Then we have in the first problem for Long.—the Lat. by D. R. and the worked out Long. In the second problem we have the assumed Lat. and the worked-out Long. Plot these Lats. and Longs. on the chart and draw a line that will connect them. To get the Azimuth, lay off a line at right angles from this Position Line. This is rather a long way to get the same results as explained.

The Lat. and Long. may be secured for all Sumner Lines by problems in navigation, but there are problems used that give better results than others at different times of the day or night.

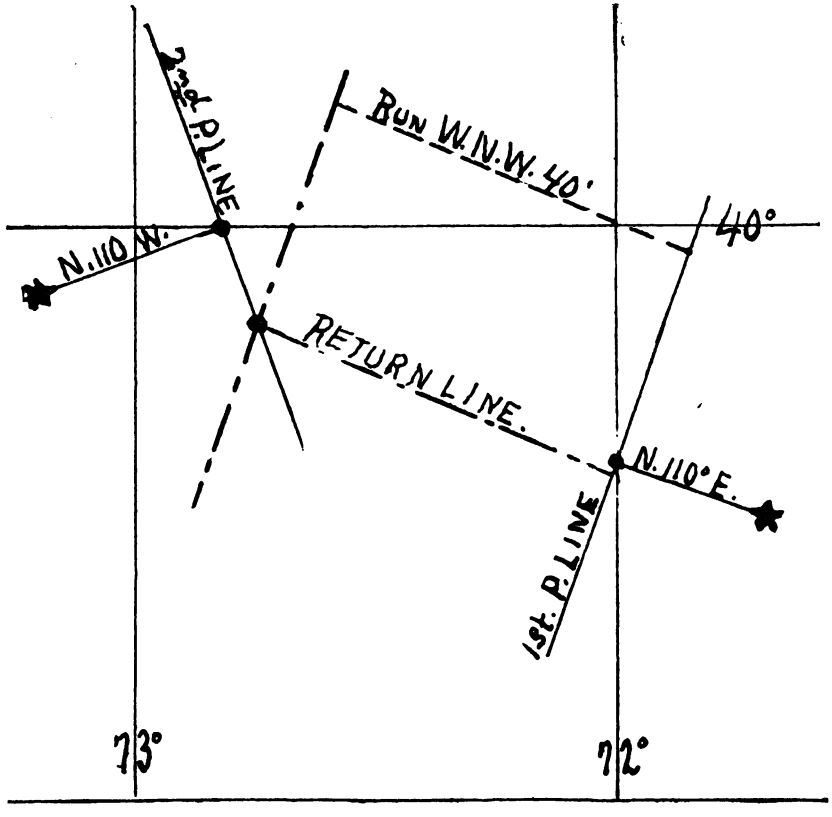
SINGLE ALTITUDE AND TIME problem may be used three hours before Noon or three hours after Noon for Latitude and Line of Position.

The EX. MERIDIAN problem may be used twenty-six minutes before or after Noon for Lat. The ST. HILAIRE problem may be used at any time to get a line of position. This method checks the Lat. and Long. at the same time and is very popular for securing these Sumner Lines.

LONGITUDE BY STAR, SUN OR PLANET may be used to get the Sumner Line. In all the problems, you must know the correct time and measure the Altitude accurately for best results. The Azimuth is the foundation of the Sumner principle, so it must be calculated or taken from the Azimuth tables, as near as possible to the Time, Lat. and Declination of the sight period.

EXAMPLES: Plot on the Sumner Chart the following—Lat. 39° 35′ N. Long. 72° W. Make a dot at this position and draw from it the Azimuth N. 110° E. Now at right angles to this line and crossing the dot, draw your First Position Line. You are some place on that line and think you are at the Lat. and Long. given or at the DOT. Now start up the engine and run Course W. N. W. TRUE 40 miles. Plot this run from any place on your First Line of Position by using the parellel rulers and the compass of the chart. Now we take the second sight for Long. and use the Lat. by D. R. to work it up. We have now Lat. D. R. 40° N. Long. by sight 72° 49′ 30″ W. Find this on the chart and make a dot. The Azimuth at this second sight is N. 110° W. Plot the Azimuth from the DOT and draw the Second Line of Position at right angles to the Azimuth Line and crossing the dot. Now bring up the First Line of Position with the parallel rulers until the edge touches the end of the Course and Distance Line. Draw the Dash and Dot line across the Second Line of Position, and you have the location of the ship by this method. To find what it is—measure off the Lat. and Long. of the spot with the dividers and consult the edges of the chart or distance rules for the Degrees, Minutes and Seconds of Lat. and Long. From this last found position draw a line parallel with the Run line (W. N. W. 40′) until it returns to the First Position Line. This shows you the corrected position at time of the first sight.

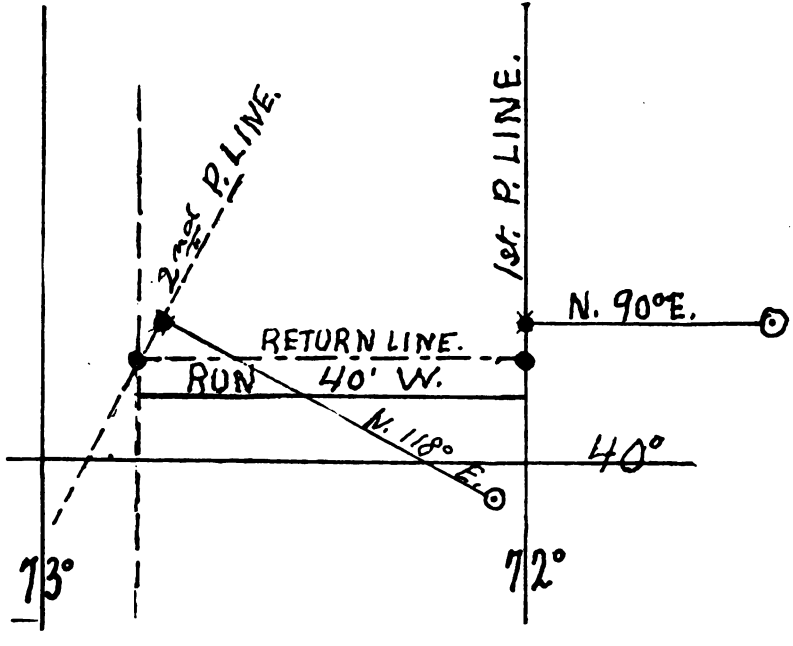
Ans. Position of ship after Run W. N. W. 40′ from first position is Lat. 39° 50′ N. Long. 72° 45′ W. Return Line places the ship at first sight in Lat. 39° 34′ N. Long. 72° 0′ 45″ W. A correction of 1′ further S. in the Lat. and 45″ further W. in the Long.


2nd. P. LINE
RUN W.N.W. 40°
40°
N. 110 W.
RETURN LINE.
N. 110° E.
1st. P. LINE
73°
72°

SCALE USED IN THE DRAWINGS ¼ INCH EQUALS 5′ LAT. ¼ INCH EQUALS 6′ LONG.

In Lat. 40° 15′ N. by D. R. Declination 10° N. Apparent Time at Ship 6.50 A. M. took sight for Long. and worked up the problem, Long. by sight 72° W. Looking up the Azimuth tables for Lat. 40° N. Dec. 10° N. and App. Time 6.50 A. M. found the Sun's True Bearing was East, or N. 90° E. Set this Azimuth Line down on chart at dot of Lat. and Long. It will be seen at once that the First P. Line runs True North and South at right angles with the Azimuth Line. Run from this position is West (true) 40 miles, when sight was again taken for Long. about 9 A. M. The Lat. 40° 15′ N. was used to secure the Long. by Observation. With this same Lat. and the new Long. 72° 45′ W. plot on the chart and make dot. The Azimuth at 9 A. M. from tables is N. 118° E. Draw the Azimuth Line to the dot and draw in the Second Position Line across the dot at right angles to the Azimuth. Now bring up the First Position Line until it crosses the end of the Run line and the Second Position Line. Give the Position of the ship and show the Return Line for correction of position at the first sight.

Ans. Lat. of crossing lines 40° 10′ N. Long. 72° 48′ W. The Return Line shows Lat. at first sight was off. It is Lat. 40° 10′ N.

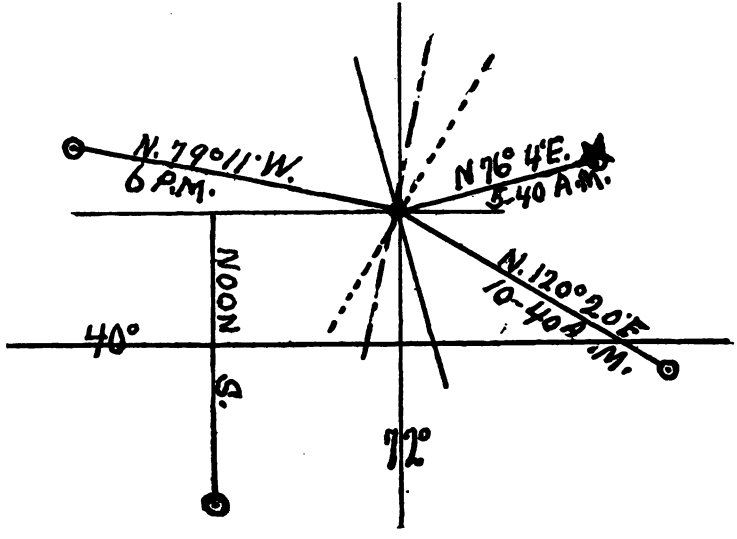


Study all the drawings carefully. The examples give the data of each drawing.

HOLDING POSITION AND SECURING SUMNER LINES

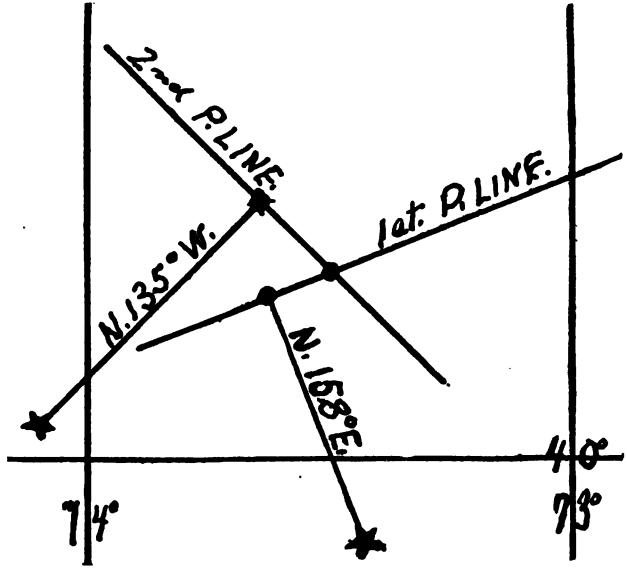
Let us assume Lat. by D. R. and Long. from star sight and several Azimuth Lines to show the crossing of Position Lines to prove our position while becalmed.

At the first sight we have Lat. 40° 14′ N. and Long. from star sight of 72° W. The Azimuth of the star is N. 76° 4′ E. at 5.40 A. M. Find the Lat. and Long. on the Sumner chart and draw the Azimuth Line to the dot, and draw the First Position at right angles to the Azimuth. At 10.40 A. M. take another sight for Long. using the Sun. Long. by sight worked up with the same Lat. showed the ship had not moved from her position. The Azimuth at this time is N. 120° 20′ E. Plot the Azimuth Line and draw another Position Line at dot. At Noon secured Latitude by the Meridian Altitude problem and proved the Lat. that had been used for the two A. M. sights was correct. Draw the Azimuth Line South and draw the Lat. line or Position Line to dot. At 6 P. M. took another sight for Long. and secured from problem Long. same as before 72° W. The Azimuth at this time is N. 79° 11′ W. Draw this Azimuth to the dot and draw another Position Line at right angles to it. The crossing of the lines will prove the ship has not changed her position.


N. 79°11' W.
6 P.M.
N 76° 4' E.
5-40 A.M.
N. 120° 20' E.
10-40 A.M.
NOON
40°
S.
72°

SURE THE LATITUDE IS OUT

Wishing to know the position of my boat as accurate as possible, I took two bearings of stars and two sights of the stars as near the same time as possible. The Latitude by D. R. was way off, and as the weather looked as if we were in for it for several days, the sights were taken before it clouded over. With the assumed latitude of 40° 17′ 30″ N. the first sight gave Long. 73° 38′ W. and the Azimuth from the tables gave N. 158° E. Plot this spot on the chart the same as before. The second sight with assumed Lat. 40° 27′ 30″ N. gave Long. 73° 39′ W. The True Bearing of the star or its Azimuth was N. 135° W. Plot this spot on the chart and show the crossing of the Position Lines. As there is practically no Run in this case the First and Second Position Lines cross each other to give the Lat. and Long. Ans. Lat. 40° 20′ N. Long. 73° 30′ W.



ST. HILAIRE METHOD FOR LINES OF POSITION

The St. Hilaire method allows of measuring the Altitude of the sun, stars or other bodies and calculating the Altitude to show position at sea. This method may be used at any time the Altitude may be measured.

The Chronometer Time must be known, the Corrected Declination and the Latitude by D. R. RULES—Find the Local Apparent Time, and get the Time Before Noon A. M. or After Noon P. M., using the L. A. T. in the Astronomical form of time. Get the Declination corrected for the G. D. Hunt up the log. Haversine for t or the Time before or After NOON. Find the log. Cos. of the Lat. by D. R. and the log. Cos. of the Cor. Dec. Now add these quantities and then find the sum as a Log. Haversine and across column will be found the Natural Haversine that corresponds. Set this Nat. Hav. down and find the Sum of the Lat. and Dec. if they have different names. Take their difference if their names are alike. Hunt this quantity up as a Natural Haversine and set it under the other Nat. Hav. Now add them, and find the sum in the Nat. Hav. for the degrees, minutes and seconds of arc that are to be subtracted, now, from 90°, to get the CALCULATED ALTITUDE.

The Observed Altitude must be secured at the instant of Chronometer Time that the Calculated Altitude came from. With the True Alt. set under the Cal. Alt., find their difference, which is called the Altitude Difference.

PLOTTING THE LINES FROM ST. HILAIRE PROBLEM

Dot the place on the Sumner chart that has Lat. and Long. of your supposed position. Find the Azimuth at time you will secure the Obs. Alt. and draw the First Line of Position at right angles to the Azimuth. When the Observed Altitude is secured and corrected to True Alt. it will show the correction of the position on the line. If the Observed Alt. is more than the Cal. Alt. space off the Alt. Diff. towards the Sun. If less, space the amount away from the Sun. This can be done by taking the number of miles on the dividers. The Azimuth line shows the place of the Sun at the end of it.

No single sight will give an absolutely correct location of the boat, so you must wait a time, and make the run on your course, and then figure out what the Calculated Alt. will be after you have run a number of miles. Say 60. At this end of the run you get the Obs. Alt. and correct it and then apply it the same way, to the Cal. Alt. to get the Alt. Diff. By plotting the Second Line of Position with the Lat. by D. R. and the Long. the same way you have another place to mark on the chart. Remember to lay off the run from the spot that shows the first Alt. Diff. Now we get the second Alt. Diff. and set it off from the Second Line of Position away or towards the Sun or star, and draw a line parallel to the position line. Then bring the First CORRECTED Line of Position down to the Second CORRECTED Line of Position until it crosses the RUN and Second Corrected Line of Position. This gives the location of the boat.

The method is very successful and allows of finding position at times when the Lat. and Long. problems would not be so accurate. The Calculating of the Cal. Alt. may be done long before the time to take the Obs. Alt. This is possible by knowing the run, the Lat. by D. R., the Long. by D. R., the Cor. Dec. and the calculated Chronometer Time, to the time you will take the Obs. Alt. to be applied to the Cal. Alt. for Alt. Diff.

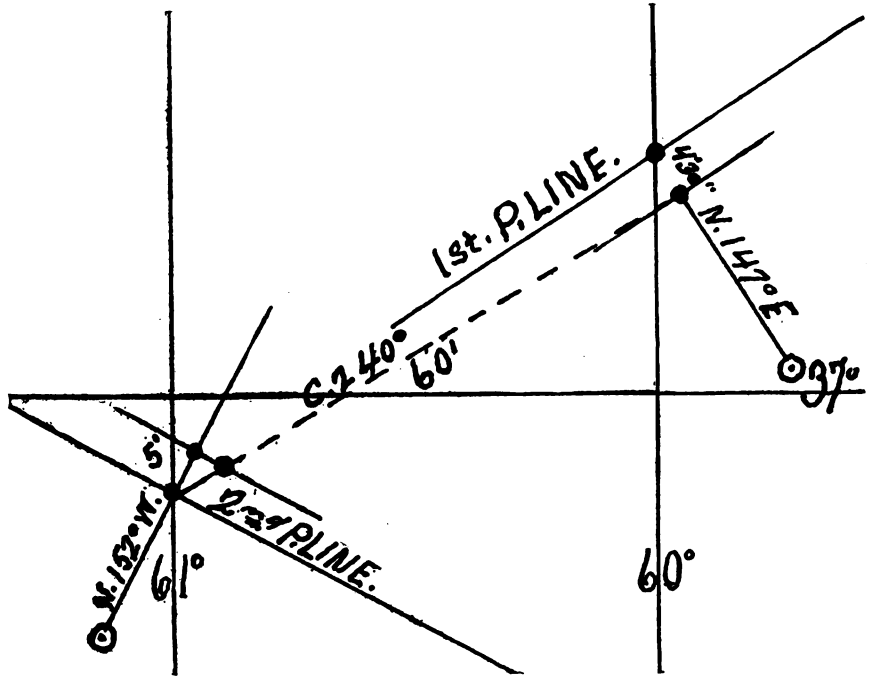
EXAMPLE:

Feb. 3rd, 1917, A. M., at ship in Lat. 37° 24′ N. and Long. 60° W. by D. R. Chronometer showed 2 hrs. 15 m. 02s. At this Chronometer time, took observation or measured the Altitude and secured Obs. Alt. 29° 7′ 24″ H. E. 15 feet. Index Error 1′ 20″ minus. Plot the position by D. R., then work up the measured Altitude by the St. Hilaire method to show the Altitude Difference. Be sure to plot the Alt. Diff. on chart. Ran from the corrected position on course 240° distance 60 miles. At end of run had Lat. 36° 45′ N. Long. 61° W. by Dead Reckoning. Plot this on the chart. Feb. 3rd, P. M., at ship 1917 C. T. showed 6 hrs 0 m. 0 s. Measured Altitude at this time and secured Obs. Alt. 31° 17′ 30″ H. E. 15 feet. Index Error 1′ 20″ minus. Lat. 36° 45′ N. Long. 61° W. Worked up the St. Hilaire method to show Alt. Diff. and plotted on chart. Show this same method on your Sumner charts.

Show crossing of Sumner Lines from A. M. sight to P. M. sight, for location of ship.

Ans. The A. M. sight L. A. T. before Noon, 1 hr. 58 m. 54 s. Dec. corrected, 16° 34′ 26″ S. Lat. N. 37° 24′. The sum of the logs for these quantities = 8.69980. Nat. Hav. corresponding to the Log. Hav. of the three logs. = 05009. Lat. plus Dec. gives Nat. Hav. 20593. These two Nat. Hav. added = 25602. This number found in Nat. Hav. gives the Arc of 60° 47′ 30″. Subtract from 90° gives Cal. Alt. 29° 12′ 30″. The True Alt. is 29° 17′ 00″ and Alt. Diff. is 4′ 30″ to be sent towards the Sun, changing the supposed position that number of miles and giving the Lat. and Long. of the first sight 37° 20′ N. 59° 57′ W.

P. M. sight. L. A. T. after Noon 1 hr. 42 m. Lat. by D. R. 36° 45′ N. Cor. Dec. 16° 32′ N. Sum of logs. 8.57303. The Nat. Hav. corresponding to this Log. Hav. is 03741. The Nat. Hav. for the sum of the Lat. and Dec. 20107 and their sum is 23848, and this looked up in Nat. Hav. gives Arc 58° 28′. Subtracted from 90° gives Cal. Alt. 31° 32′. The True Alt. 31° 27′ is less, so the difference between the Cal. Alt. and True Alt. is applied away from the Sun for the corrected position. The Corrected First Position Line is brought up to cross the Second Corrected Position Line and Run. Location of crossing of these lines and place of boat at second sight is Lat. 36° 52′ 30″ N. Long. 60° 54′ W. The Azimuth for First Line of Position is N. 147° E. For the Second Line of Position N. 152° W. They are found by knowing the L. A. T., Dec. and Lat. at time of the sights from the Azimuth tables or by calculation.


1st. P. LINE.
43°
N. 147° E
37°
G. 2 40°
60'
5'
N. 152° W.
2nd P. LINE.
61°
60°

LINES OF POSITION BY DOUBLE LAT. AND LONG.

In this work the Lat. is assumed and the Long. sight worked with it. Then another Long. problem is worked with another assumed Lat. within 30′ of the first Lat. This gives us two spots to mark on the chart to get the First Line of Position. The RUN is made and the course and distance noted from the first sight until the second sight. Here, again, we take a sight for Long. and use the same assumed Lats. for the two problems in Long.

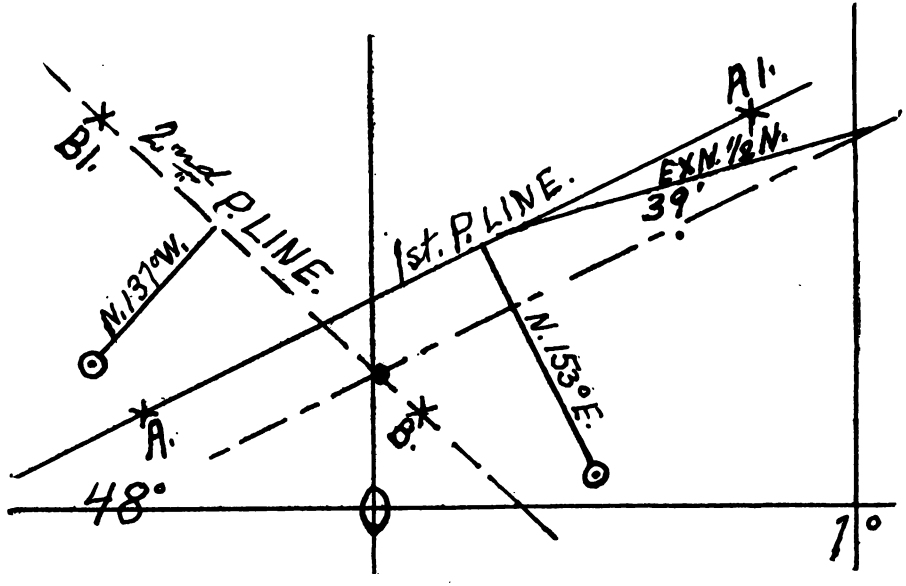
These two spots are placed on the chart. The Run is set off from the compass rose of the chart and the proper distance marked. Now bring the First Line of Position up to the Course Line and to the Second Line of Position, and where they cross is the location of the ship. Now take off with the dividers the Lat. and Long. of this crossing of the two lines, to have the Lat. and Long. IN.

EXAMPLE: Lat. A 48° 10′ N. Long. of A after working up the problem is 0° 29′ 45″ W. Spot this place on the Sumner chart. Lat. Ai. 48° 40′ N. and the Long. secured from the problem is 0° 49′ 45″ E. Spot this place on the chart and join the TWO PLACES together for the First Line of Position. The Run is made now on course E. X. N. ½ N. 39 miles. Then we take another sight for Long. and work with the same assumed Lats. Lat. of B, 48° 10′ N. used with the Long. problem gave Long. of B, 0° 5′ 15″ E. Set this spot on the chart. Lat. of Bi. is 48° 40′ N. and the Long. secured from problem is for Bi. 0° 34′ 15″ W. Place this spot on the chart and draw a connecting line for the Second Line of Position.

We have now four spots on the chart showing each Lat. and Long. We have two lines drawn from these spots as the Position Lines. Now draw in the RUN and send the First Line of Position, parallel, to the end of the RUN and make it cross the Second Line of Position for your location of the ship by this method.

Show the Azimuth for the first and second positions. This is done by drawing at right angles, to the Position Lines, a line, and then find its angle from the compass rose.

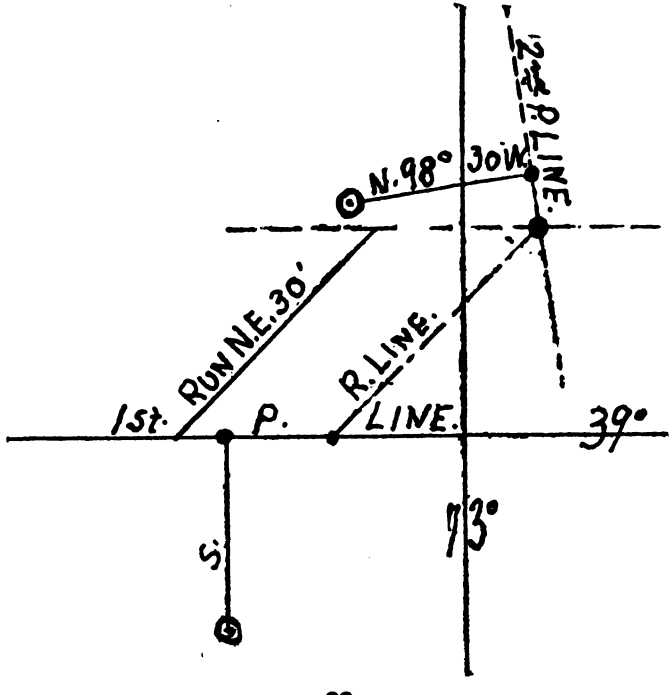
Ans. Position of ship by crossing of lines is Lat. 48° 14′ N. Long. 0° 1′ 0″ E. The ship is about on the Meridian of Greenwich. The Azimuth for the first line is N. 153° E. Second Azimuth is N. 137° W.



Show the Lines of Position from the following: Lat. from the Meridian Altitude problem at Noon placed the ship in Lat. by Obs. 39° N. Long. by D. R. 73° 30′ W. Felt sure the Long. was out, so ran True Course N. E. 30 miles and secured Azimuth from the tables N. 98° 30′ W. and took sight for Long. Used the Lat. since Noon up to end of Run and had for the Second Line of Position Lat. 39° 27′ 30″ N. Long. from sight, 72° 51′ W. Bring up the First Line of Position, which is, in this case, Lat. 39° N. until

it crosses the end of the Run and Second Line of Position to show the location of the ship at time of second sight.

Ans. Lat. 39° 21′ 12″ N. Long. 72° 50′ W. is position by lines crossing. The Return Line would show Long. at Noon 73° 15′ W. The Position Line for the Noon sight runs E. and W. The Azimuth runs S.



AZIMUTH OR TRUE BEARING OF THE SUN OR STARS

It is required to take from the Azimuth Tables the True Bearing of the Sun for a certain Apparent Time at ship, so that this bearing may be compared with the Compass Bearing of the Sun or Star to secure the Deviation of the compass when the ship is heading on some course at the time the bearing was taken.

The Sun's True Bearing may be found by hunting up the Lat. in, the Declination of the time of taking the bearing and the Apparent Time at Ship from the Azimuth Tables. Be careful that the Lat. and Dec. are taken from heading of pages of same names or of opposite names. This occurs when you are in N. Lat. and the Sun is S. Dec. for different names. The times must be taken from the A. M. or P. M. columns in accordance with the A. T. at S. The Azimuth is named as the bottom of the pages state. If N. Lat. and A. M., the True Bearing is N. so many degrees E. If P. M., the Azimuth is N. so many degrees W. In S. Lat. the Azimuth of the Sun is named S. and E., for the A. M. time and S. and W. for the P. M. time.

The Compass Azimuth should be changed to read the same in letters as the True Bearing. EXAMPLES from AZIMUTH TABLES—Lat. 8° N. Dec. 20° N. A. T. 8 A. M. Azi. N. 71° 26′ E. Lat. 15° N. Dec. 22° N. A. T. 3 P. M. Azi. N. 73° 40′ W. Lat. 35° N. Dec. 14° N. A. T. 2 P. M. Azi. N. 120° 20′ W. Lat. 37° N. Dec. 12° S. A. T. 4 P. M. Azi. N. 118° 31′ W. Lat. 51° N. Dec. 23° S. A. T. 1 P. M. Azi. N. 165° 44′ W. Lat. 39° S. Dec. 21° N. A. T. 10 A. M. Azi. S. 149° 20′ E. Lat. 23° S. Dec. 20° N. A. T. 3 P. M. Azi. S. 130° 51′ W.

TRUE AZIMUTH OF STARS—To take the Azimuth of stars from the Azimuth Tables you must get the L. S. T., the star's R. A. and then the H. A., and find the True Azimuth in the P. M. columns corresponding to the Hour Angle.

RULES—To the A. S. R. A. add the A. T., expressed astronomically. The sum will be the L. S. T. To be more accurate, you can add the correction of the R. A. for the number of hours past Noon at Greenwich. Subtract the Right Ascension of the star or planet, or the L. S. T., and the remainder will be the Hour Angle to be used in the P. M. column to find the Azimuth. The Azimuths are named just like the Sun's Azimuths, for the N. or S., but named E. or W., as the body is E. or W. of the L. S. T.

EXAMPLES—June 10th. Apparent Sun Right Ascension 5h. 12m. 11s. A. T. at S. 10 P. M. and Long. 75° W. or 5hrs. cor. to R. A. plus 2m. 34s. L. S. T. 15h. 14m. 45s. Regulus R. A. from star list of Nautical Almanac, 10h. 03m. 59s. H. A. 5h. 10m. 46s. the P. M. Column gives the Azi. under Lat. 40° N. and Dec. of the star 12° 22′ N. Ans. True Azi. N. 88° W. RULE—L. S. T. BEST—Star is W. Local Sidereal Time LEAST, the Star is E.

March 10th. A. T. at S. 11h. 40m. 20s. P. M. Long. 60° W. A. S. R. A. 23h. 20m. 53s. cor. for Long. and T. at S. (14h. 40m.) gives 2m. 24s. L. S. T. 11h. 3m. 37s. Procyon R. A. 7h. 35m. 00s. H. A. 3h. 28m. 37s. Dec. of Star 5° 26′ N. Lat. 42° N. Ans. Azi. N. 113° W.

May 15th. 2h. 20m. 40s. A. M. at Ship A. T. makes Astronomical T. May 14d. 14h. 20m. 40s. A. S. R. A. 3h. 22m. 48s. Cor. for Long. 75° W. and A. T. at S. 3m. 10s. plus L. S. T. 17h. 46m. 38s. Spica's R. A. 13h. 20m. 52s. H. A. is 4h. 25m. 46s. W. Gives Azi. N. 112° W. Using Lat. 28° N. and star's Dec. of 10° 44′ S.

FINDING THE DEVIATION—After securing the True Azi. and having the Compass Azimuth or the bearing of the body by the compass, you find the total error of the compass on the heading of the ship at the time of taking the bearing. This Com. Azi. goes under the True Azi. and subtracted one from the other.

NAMING THE ERROR—If the True Azi. is to the right of the Comp. Azi. the error is named East, and if to the left, it is named West.

NAMING THE DEVIATION—The Variation is set down under the Error and subtracted if of same name as Error, one from the other. If the Vari. is greater than the Error, the Devi. is named opposite name from the Error. If less, that Error you must watch the rule that calls for naming the Devi. as the Error falls to the right or left of the Vari. If Error is to the right of Vari. the Devi. is E., if to the left of Vari. the Devi. is W.

When the Error is nothing the Devi. is the opposite name of the Vari.

When the Vari. is nothing the Devi. is same name as the Error.

Variation minus Error gives Devi., opposite name to Error when the Vari. is same name as Error.

Deviation is the same name as Error when Variation is less and added to, or subtracted from Error.

OBTAINING THE TRUE AZIMUTH ACCURATELY

Suppose we wanted to know the accurate True Azimuth from the following:

Apparent Time 4h. 26m. Dec. 19° 46′ 00″ N. Lat. 37° 25′ 00″ N. It would be set down in columns. The base must be secured for the nearest hour and ten minutes, the number of degrees of Dec. and Lat., and then set down as the first line. Then the Azimuth is taken off for lower and higher time, Dec. and Lat. The odd minutes are calculated by the difference of the Azimuth columns.

Example.

1.	Time 4h. 20m.	Azi. 88° 42′	Dec. 19°	Azi. 88° 42′	Lat. 37″	Azi. 88° 42′	Base
2.	Time 4h. 30m.	Azi. 87 14	Dec. 19	————	Lat. 37	————	
3.	Time 4h. 20m.	————	Dec. 20	Azi. 87° 42′	Lat. 37	————	
4.	Time 4h. 20m.	————	Dec. 19	————	Lat. 38	Azi. 89° 18′	
Azi.	Difference for 10m.	88′	for 1°	60′	for 1°	36′	
	Difference for 1m.	8.8′	for 1′	1′	for 1′	.6′	
	Difference of Time	6m.	of Dec.	46′	of Lat.	25′	
	Difference for 6m.	-52.8′	for 46′	-46′	for 25′	+ 15.0′	

Add the quantities that have the minus sign and subtract the plus quantity, gives us 1° 23′ 48″ as the correction to the Base. This is subtracted because the minus quantities were greater.

Ans.—The Accurate True Bearing from the Azimuth Tables with the quantities given in the example is 87° 18′ 12″.

The Azimuths are subtracted one from the other as the "Azi. Difference" will show. The Difference for 1m. and 1′ and 1′ multiplied by the Balance of Time, Dec. and Lat. and marked minus and plus, as the Azimuth decreases in the Time column, the Declination column and increase in the Latitude column.

DEVIATION BY AZIMUTHS—Turn the Compass Bearing into the same name of Arc as the True Azimuth. Subtract one from the other and name Error as per rules given. Set down the Variation under Full Error and subtract or add as per rules. Balance is Deviation.

EXAMPLES—T. Azi. N. 71° 26′ E. Com. Bearing, E. N. E. turned into Com. Azi. gives N. 67° 30′ E. Vari. 8° 56′ E. Give the Deviation. Ans. 5° W.

T. Azi. N. 73° 40′ W. Comp. Bear. W. N. W. Vari. 4° 10′ W. Give Deviation. Ans. 2° W.

T. Azi. N. 120° 20′ W. Comp. Bear. W. X. S. Vari. 4° 20′ E. Give Deviation. Ans. 23° 25′ W.

T. Azi. N. 118° 31′ E. Comp. Bear. S. E. X. E. ¼ E. Vari. 10° 20′ 10″ W. Give Deviation. Ans. 7° 54′ 55″ E.

T. Azi. S. 149° 20′ E. Comp. Bear. N. E. X. N. Vari. 8° 10′ E. Give Deviation. Ans. 11° 15′ W.

T. Azi. N. 110° W. Comp. Azi. N. 100° W. Vari. 10° W. Give Deviation. Ans. 0.

T. Azi. N. 113° W. Comp. Azi. N. 100° W. Vari. 2° E. Give Deviation. Ans. 15° W.

T. Azi. N. 112° W. Comp. Azi. N. 120° W. Vari. 4° E. Give Deviation. Ans. 4° E.

DON'T FORGET that the compass must be used in degrees from North to East 180° and from North to West 180° for Azimuth problems, when in North Lat. and South to East 180° and South to West 180° when in South Lat.

The True Azimuth or Bearing (both meaning the same) can have the Variation applied to it at once, which turns the True Azimuth into Magnetic Azimuth. This Azimuth has the same name as the True Azimuth.

ADDING OR SUBTRACTING THE VARIATION—Remember that the True Azimuth is the same as a True Course and the Variation must be applied just the same to secure the Magnetic Azimuth.

RULE I. If True Azimuth is N—E. and Variation is E. the Vari. goes to the left of the True Azi. If the True Azi. is N—W. and the Vari. E. the Variation goes to the left of the True Azi.

WHY? If you have a True Course and wish to turn it into a Magnetic Course by application of the Variation, you know very well the Variation must be changed, the number of degrees it has, just the opposite to the name of the Variation. OR—E. Vari. goes to left that much and W. Vari. goes to the right that much, to get the Magnetic Course.

RULE II. In taking up these rules for Azimuth naming, you can follow this formula. FORMULA: Set down the True Azi. taken from the Azimuth Tables for the Lat. Declination and Apparent Time of taking the bearing of the Sun or star. Follow this with the Variation, which is taken from the chart in the section you are sailing. Either subtract or add the Vari. to get the Magnetic Azimuth. Remember that the same name is given the Mag. Azi. as the True Azimuth. Now place the Compass Azimuth, or bearing by compass of the object, under the Mag. Azi. and subtract one from the other. NAMING THE DEVIATION—If the Magnetic Azimuth is to the RIGHT of the Comp. Azi. the Deviation is East. If it is to the LEFT, the Deviation is West.

EXAMPLES, first rule—True Azi. N. 150° 20′ E. Vari. from chart 20° 20′ W. Mag. Azi. N. 170° 40′ E. True Azi. N. 120° 30′ W. Vari. 20° 30′ W. gives Mag. Azi. N. 100° W. True Azi. S. 88° 40′ W. Vari. 10° E. gives Mag. Azi. S. 78° 40′ W. True Azi. N. 108° W. Vari. 18° E. gives Mag. Azi. N. 126° W. True Azi. S. 70° 57′ E. Vari. 6° 16′ W. gives Mag. Azi. S. 64° 41′ E.

Remember that the words "goes to the left or right" mean that you make the Magnetic Azimuth a greater or less quantity by adding or subtracting the Variation.

Look from the center of the Compass Card to the Azi. to be sure which direction the Vari. goes.

EXAMPLES, second rule—We have now the Magnetic Azi., so let's find out the Deviation. We have taken the bearing of the Sun or star at a certain Apparent Time and made a note of the Heading of the Ship, at this time, and the bearing of the Sun or star. This bearing will generally be in points, quarter points, or degrees; if the Compass is marked that way. This bearing must be turned into the same name as the Magnetic Azi. To do this, you may take the bearing at once from the compass card in this book, in Azimuth, by naming the bearing N—E. in the A. M. and N—W. in the P. M. or S—E. and S—W.

DEVIATION—Set under the Mag. Azi. the Compass Azimuth and subtract one from the other; the balance is Deviation.

Mag. Azi. N. 120° 40′ E. Comp. Azi. N. 115° 20′ E. Devi. 5° 20′ E. The Mag. Azi. is to the right of the Comp. Azi. Devi. is East. Mag. Azi. N. 156° 20′ W. Comp. Azi. N. 154° 10′ W. Devi. 2° 10′ W. The Mag. Azi. is to the left of Comp. Azi.

FORMING A DEVIATION CARD

Should you wish to know the Deviation of your compass while sailing a certain location, on a cruise, or long voyage, it may be done by just the work we have gone over.

Take the bearing of the Sun on the four Cardinal Points of the compass and then take the bearings of the Sun or star for the Inter Cardinal Points.

You must know the Apparent Time for each bearing, the Lat. of your place, and the Sun's Cor. Declination. With this dope, you consult the Azimuth Tables to secure the True Azimuth of the Sun or star. Now get the Deviation by the rules given.

Be sure to set down the Deviation for each of the courses the boat was headed and remember that the Deviation only applies to each separate course the boat was on, at the time of taking the bearing. By taking Compass bearings of the Sun on the eight principal points of the compass you can get a goodly Deviation Card.

FORM DEVIATION CARD from the following dope—Yacht heading N. by yacht's compass, 7 A. M. Lat. 40° N. Declination of the Sun 6° N. The compass bearing of Sun was N. 100° E. Vari. from chart 8° W.

Use the same Lat. and Dec. and Variation for the following Compass Bearings. Yacht heading E. at 7.20 A. M. Comp. Azi. N. 104° E. Heading S. 7.40 A. M. Comp. Azi. N. 106° E. Heading W. 8 A. M. Comp. Azi. N. 110° E. Heading N. W. 8.20 A. M. Comp. Azi. N. 118° 23′ E. Heading N. E. 8.40 A. M. Comp. Azi. N. 124° 30′ E. Heading S. E. 8.50 A. M. Comp. Azi. N. 126° 38′ E. Heading S. W. 9.10 A. M. Comp. Azi. N. 140° 13′ E.

ANSWERS FOR DEVIATION—Headings, N. E. S. W. Deviations, 3° E. 2° E. 4° E. 3° 30′ E. Other headings 1° W. 3° W. 3° W. 12° W.

APPLYING THIS DEVIATION: Should you desire to steer a certain Magnetic Course after laying it off on your chart, you must apply the Deviation to the Magnetic Course, found from this Deviation Card, to give you the steering or Compass Course.

EXAMPLES: Magnetic Course to take you to the light ship is North. On that course your card says Deviation 3° E. Steer Compass Course N. 3° W.

Magnetic Course to the Point, E. Steer by compass E. 2° N.

Magnetic Course to the stone-pile off Cape May, South. Steer S. 4° E.

Magnetic Course taken from the chart to light ship is W. Steer W. 3° 30′ S.

Magnetic Course to the big rock, N. W. Steer N. W. 1° N.

Magnetic Course to the island, N. E. Steer N. E. 3° E.

Magnetic Course to the buoy, S. E. Steer S. E. 3° S.

Magnetic Course to the entrance of the inlet, S. W. Steer S. W. 12° W.

This shows the value of a Deviation Card.

RULE—Change the Magnetic Course or Bearing to a Compass Course or Bearing by applying the Deviation of the compass. East Deviation goes to the left and West Deviation goes to the right of the Magnetic Course.

Take the first example. You have, from the Devi. Card on North, 3° E. The Mag. Course is given from the chart as North. Now if your old compass has been pulled around to the East 3° and your North point then is that much off, you must bring the amount around the other way to be right, when steering Compass Course, to be heading Magnetic North. So with the others.

You will have a lot of pleasure working this out on your boats. When you have a large Deviation, you may secure two small magnets, made for correcting the compass, and try to do some adjusting of that compass by laying the magnets near the compass and trying a new Deviation Card, or running over some courses that are marked on your chart.

A good plan is to run the range lights to see how far the magnets are to be placed. Of course this is the adjuster's work and should be done by him, but for pleasure and having a fling at it, you may try the work with some success.

THE ALTITUDE AZIMUTH

The Altitude Azimuth problem gives you the Azimuth of bodies at the same time you measure their Altitude when taking a sight. With this Azimuth you may lay down a Position Line or get the Deviation of the Compass. The quantities required are the True Altitude, the Latitude by D. R. the Polar Distance and, of course, the Declination. The time is known by the taking of the sight or measuring the Altitude.

Correct the Declination to the G. D. and dig up the Polar Distance by adding 90° to the Cor. Dec. if the Lat. and Dec. have different names, or one South and the other North. If they have same name, subtract the Cor. Declination from 90° for the P. D.

No correction to Declination of Stars when Azimuth is found.

Now add the three quantities (the True Alt., the Lat. and the P. D.). Then divide by 2 for the Half Sum. Then subtract the Half Sum from the P. D. and call it the Remainder.

LOGS OF QUANTITIES: Find, from the Bowditch Tables No. 44, the Secant of the True Alt., the Secant of the Latitude and the Cosine of the Half Sum; also the Cosine of the Remainder. The 10., index of the logs, is dropped. Add the logs and divide by 2 for the Half Sum of Logs. Name this Half Sum of Logs Cosine, and find it in the tables for Arc. This will give one-half of your Azimuth, so you must multiply by 2. This gives you the True Azimuth.

NAMING THE TRUE AZIMUTH: The Azimuth is named exactly like the Azimuth from the Azimuth Tables by using this problem. There are several other formulas that give Azimuth, but you are at a loss to name your Azimuth after getting the answer, that is the reason this rule is advised.

The True Azimuth is named North, when in North Latitude, and East, if the body is still increasing its Altitude, or North and West, if the body is decreasing its Altitude. Just the opposite in South Latitude.

All there is to remember—North Lat. and A. M. Azimuth named N—E. North Lat. and P. M. Azimuth named N—W. Opposite for South Lat.

The Stars work the same way, but if East of the Meridian or West, they are named that way of course. You keep the North or South names just the same for the first letters of the Azimuth.

EXAMPLES—True Altitude 24° Sun bearing W. Lat. 38° 46′ N. Declination 7° 55′ 18″ S. Give the True Azimuth. Ans. True Azimuth N. 123° 26′ W. The half Azi. is found, lower part of page, with the minutes on right-hand side of pages equal 61° 43′. P. D. 97° 55′ 18″.

TAKING OUT THE DEGREES: You will find the smaller numbers are to be used always for the half Azimuth on each page of Table 44.

True Alt. 17° 16′ 05″. Lat. 50° 43′ N. P. D. 69° 57′ 10″ P. M. at ship. Give the True Azimuth. Ans. Half Sum of the logs 9.88670. Cos. gives Half Azi. 39° 37′. True Azimuth N. 79° 14′ W.

True Alt. 16° 25′ 19″ Lat. by D. R. 13° 54′ 00″ S. Cor. Dec. 23° 19′ 43″ N. P. M. at ship. Sun bearing by compass, West, Variation from the chart 0° 0′ 0″. Give the Deviation of the compass. Ans. Half sum of logs, 9.69975. The Cos. of this number gives half of the Azimuth 59° 56′. True Azimuth S. 119° 52′ W. The Azimuth is named from the rules. Variation nothing, the Mag. Azi. is the same as the True Azi. The Compass Azimuth is West or South 90° West, the same thing. Subtracted from the True Azimuth gives the Deviation 29° 52′ E. The True Azi. is to the right of the Comp. Azi. Devi. is East.

True Alt. 27° 16′ 12″. Lat. 38° 46′ N. P. D. 97° 41′ 56″ A. M. at ship. Compass bearing of the Sun. S. E. X. E. Variation from the chart, 20° E. Give Deviation of compass.

Ans. One-half sum of the logs, 9.64653, and Cosine of this number gives half the Azimuth, 63° 41′. True Azimuth N. 127° 22′ E. The Variation is applied to the left to get the Mag. Azi. The Comp. Azi. equals N. 123° 45′ E. Subtracted from Mag. Azi. gives the Dev. 3° 17′ E.

AMPLITUDES AND HOW TO USE THEM

The Amplitude of a heavenly body is secured to find out the Deviation of your compass. The True Amplitude, Magnetic Amplitude and the Compass Amplitude are required to get the answer.

The Sun or some other heavenly body must be observed for its Compass Amplitude (or Compass bearing) as it rises to a height of half the diameter of the Sun above the Visible Horizon. At this time secure the bearing of the Sun by your compass and note the heading of the boat. The problem will give the Deviation of that heading only.

The Latitude, Corrected Declination are looked up in Table 39 of Bowditch to secure the True Amplitude. The table shows degrees and tenths of a degree, so you must multiply the tenths by 6 to get the minutes of arc.

NAMING THE AMPLITUDE—If the Declination is N. and the Sun rising, the True Amplitude is named E————N. If the Declination is S. and the Sun setting, the True Amplitude is named W————S. If Dec. is N. and Sun setting, name is W————N. If Dec. is S. and Sun rising, True Amplitude is named E————S.

APPLYING THE VARIATION—Take from the chart of your location the Variation and apply it to the True Amplitude, just the same as if it were a True Course, to be turned into a Magnetic Course. This means you apply the Var. the way the opposite name of Variation. Var. E. goes to the left, Var. W. goes to the right to secure the Magnetic Amplitude.

MAGNETIC AMPLITUDE is named just the same as the True Amplitude. Having the Magnetic Amplitude, you set under it the Compass Amplitude, which is the bearing by compass of the Sun, and subtract one from the other, if of SAME name. If DIFFERENT names, add them for Devi.

NAMING THE DEVIATION—If the Magnetic Amplitude is to the right of the Compass Amplitude, the Deviation is named East. If to the left, the Deviation is named West.

Try to imagine yourself in the center of the compass card, so that you will know which is right and left. Always look towards the Compass Amplitude, and you will see if the Magnetic Amplitude is right of it or left of it.

The pleasure of boating is tenfold more attractive when you get to working problems in navigation, and the use of the Azimuths and Amplitudes for the correction of your compass is a delight many of you have missed.

The Azimuth Tables allow of securing the True Bearing of the Sun for every ten minutes, but the use of the Amplitude Tables stint you to Sunset and Sunrise.

USE OF THE AMPLITUDE—You get up a little before Sunrise and stand by your compass ready to take a bearing of him, as his Lower Limb is half his diameter above the horizon. If your compass has a sight-vane, you now take the Compass Amplitude or bearing.

Correct the Declination and look up the Lat. and the Cor. Dec., Table 39 Bowditch, for the True Amplitude, and work the rules given for the Deviation. Now do this same thing again at Sunset. If you wish to tackle the Azimuths during the day, do so, and get more corrections to that compass. Remember to head on different courses each time you take a bearing and set down the Deviation for the heading of the boat, so that you will know how much that old compass is off on the several points.

EXAMPLES—Lat. 25° N. Dec. 8° 30′ N. Variation 1° 40′ E. Compass Amplitude E. 2° 49′ N.

Sun rising, Dec. N. the True Amplitude is marked E————N. Give the Deviation from the Amplitude tables.

Ans. True Amp. E. 9° 24′ N. Deviation 8° 15′ W.

REMEMBER—The Amplitudes are measured each side of East and West 90°.

Lat. 56° N. Dec. 23° N. Com. Amp. North or W. 90° N. Vari. 30° W. Sun setting and N. Dec. True Amp. is W————N. Give the Deviation.

Ans. Magnetic Amplitude W. 74° 18′ N. Deviation 15° 42′ W.

AMPLITUDE WITH DIFFERENT NAMES—You must add the Mag. Amp. and the Comp. Amp. for Deviation.

EXAMPLES—Mag. Amp. W. 10° 20′ N. Comp. Amp. W. 2° 8′ S. Devi. 12° 28′ E.

Mag. Amp. E. 20° 8′ N. Comp. Amp. E. 1° 8′ S. Devi. 21° 16′ W.

Mag. Amp. E. 4° 20′ S. Comp. Amp. E. 2° 00′ N. Devi. 6° 20′ E.

Mag. Amp. W. 8° 10′ S. Comp. Amp. W. 1° 2′ N. Devi. 9° 12′ W.

The Deviation is named as before. That is, Mag. to right of Comp. Amp. Devi. is East; Mag. Amp. to left of Comp. Amp. Devi. is West.

Lat. 50° N. Dec. 13° S. Comp. Amp. W. 2° 48′ 45″ N. Vari. 30° 30′ W. Sun setting and Dec. S. gives T. Amp. W————S. Give the Deviation.

Lat. 24° 40′ S. Dec. 0° 0′ 0″. This makes the True Amp. East. Comp. Amp. E. 2° 50′ N. Vari. 7° 40′ W. Sun rising and Dec. 0° gives T. Amp. E————N. Give the Deviation.

Ans. Var. applied to the True Amp. gives Mag. Amp. E. 7° 40′ S. The Amp. has changed quadrants. Deviation is 10° 30′ E.

Lat. 55° N. Dec. 22° 30′ S. Comp. Amp. S. E. ½ E. Vari. 36° 20′ W. Sun rising Dec. S. gives True Amp. E————S. Give the Deviation.

Ans. As the Amplitudes must have same names, change the Comp. Amp. to name of True Amp. gives E. 39° 22′ 30″ S. Deviation 38° 51′ 30″ E.

THE TRUE AMPLITUDE BY CALCULATION—The True Amplitude may be secured by the Bowditch Table No. 44. Take out the Secant of the Latitude and the Sine of the Corrected Declination and then add the two logs. Now dig up the Sine of the Sum of these two logs for the True Amplitude and name it the same as you did in the other rule. The Variation is to be applied just the same, and the Deviation will be within a minute or so of the Tables.

EXAMPLES—Lat. 62° 30′ N. and Dec. 24° N. using the Sec. of the Lat. and the Sine of the Dec. gives sum of logs 9.94490. Remember, you must drop the 10. of the index of the Sec. Give the True Amp.

No. 1. Ans. True Amp. W. 61° 45′ N. Sun setting.

No. 2. Lat. 55° N. and Dec. 22° 30′ S. Give the True Amp. Ans. True Amp. E. 41° 51′ S. Sun rising.

No. 3. Lat. 50° N. and Dec. 13° S. Give the True Amp. Ans. True Amp. W. 20° 29′ S. Sun setting.

No. 4. Lat. 25° N. and Dec. 8° 30′ N. Give the True Amp. Ans. True Amp. E. 9° 24′ N. Sun rising.

No. 5. Lat. 56° N. and Dec. 23° N. Give the True Amp. Ans. True Amp. W. 44° 20′ N. Sun setting.

Example No. 1 has Vari. 8° W. and Comp. Amp. W. 60° 45′ N. Devi. is 9° E.

Example No. 2 has Vari. 10° E. and Comp. Amp. E. 30° 00′ S. Devi. is 1° 51′ E.

Example No. 3 has Vari. 5° W. and Comp. Amp. W. 5° 00′ S. Devi. is 10° 29′ W.

Example No. 4 has Vari. 8° W. and Comp. Amp. E. 6° 00′ N. Devi. is 4° 36′ E.

Example No. 5 has Vari. 14° E. and Comp. Amp. W. 30° 20′ N. Devi. is 0° 0′ No Devi.

Remember to send the Variation the proper way.

The Amplitudes commence at East or West and increase their quantities going towards North or South, and decrease as they come near East or West. This must be remembered when applying the Variation to secure the Mag. Amp.

West Variation is applied to the right of True Amp. for Mag. Amp., and East Variation is applied to the left of the True Amp. for the Mag. Amp.

ALLOWANCE FOR CURRENT

SET and DRIFT are the names given to the tide or current when they are to be allowed for in chart work or navigation.

SET, means direction to which the current goes. It is not like the wind. We say Northeast wind and meaning direction from which the wind comes.

DRIFT, means speed of the current.

In navigation off shore, a record of the set of the current is kept by careful Dead Reckoning and Observations. When there is a difference between the D. R. and the Observation, there is said to be a current, and the amount of same and its direction may be plotted from the Lat. supposed to be in by D. R., also the Long. and the position by observation.

As the Dead Reckoning is generally out somewhat, the current calculation is not positive by a whole lot. There are times when D. R. will give a fair position and then, should the observations show considerable change in the position, the current may be allowed with fairness.

The Gulf Stream is so well known with its Set and Drift that navigators make allowances from the instant they reach that warm body of water, flowing through the ocean, until they are clear of it. During the run in such an ocean-river, as it were, the current may not be calculated to a nicety and the cruiser placed out of her direct course to her port, when the observations are secured and the Sumner Lines laid down. Now, if the weather happens to be stormy and loads of rain coming down for three days or more, the current may prove a factor that may either lose or win a race for you. Working on D. R. under these conditions, you do not get the Sun or stars to check up by the sights and must depend upon D. R. until that time happens, when old Mr. Sun shoots out and you grab his Altitude for the Lat. and Long. Then, and only then, will the current (or poor steering) show up to your disgust.

WITH OR AGAINST CURRENT—It must be seen at once, should the current with two miles per hour drift be with the yacht, that much must be added to her speed over a certain run and just the opposite when the current is against her.

EXAMPLES—Course N. W. Clover making 8 knots per hour. Current sets N. W. with drift of 2 miles per hour. Clover making 10 knots per hour on that course.

Mabel making 10 knots per hour. Current sets S. E. 3 miles per hour. Mabel on a N. W. course. She is making 7 knots per hour.

CURRENT COURSE BY TRAVERSE TABLE—When we have a known current, its set and drift, it is put down in the Traverse Form as a course, with the miles of drift used as Distance. When the Diff. Lat. and Dep. are taken out for each course, it is also taken for the Current course to get the Course and Distance Made Good (C. D. M. G.).

EXAMPLES—True Course N. E. run or distance 25 miles. Current sets E. N. E. with drift of 14 miles for the time sailed on the N. E. course. Give the Course and Distance Made Good.

RULES—Find the Diff. Lat. and Dep. for the N. E. course with Dist. given, also the Diff. Lat. and Dep. for the Current course and distance. If the Diff. Lat. and Dep. have same name, add them, if of different names, subtract them one from the other. Don't do this with one Diff. Lat. and one Dep. Meaning—that Diff. of Lat. one S. and the other N., are to be subtracted. Departure, one E. and other W., then subtract and you will have then the True Diff. Lat. and Dep. to look up in the Tables

No. 2 of Bowditch, and where they compare in the columns will be found the Distance made good; and the top or bottom of page will give the Course made good. In this example we have for Diff. Lat. of N. E. Dist. 25 miles, 17.7, and its Dep. is 17.7. The Current course gives Diff. Lat. 5.4 and Dep. 12.9. As they are both N. and E. you add the two Diff. Lats. and the two Dep. for the True Diff. Lat. and Dep. making Diff. Lat. 23.1 and Dep. 30.6. Now find them in the table No. 2.

Ans. Course Made Good, N. 53° E. Distance Made Good, 38 miles.

NAMING THE COURSE—There is no trouble in naming the Course made good as you have the required letters from the Traverse Form after the quantities have been added or subtracted.

DRAWING THE COURSE AND DISTANCE MADE GOOD—This may be done by drawing a circle and marking off the four Cardinal Points of the compass, but remember the compass is a true one. A scale must be used to get the distance on each course. Say you use ⅛-inch to be a mile. Now lay off the first course N. E. 25 miles in its proper direction from the center of the compass you have drawn. At the end of this 25-mile line set off the Current course with its proper distance, using the compass and parallel rulers to get the right direction. Be careful to set the Current course on the proper side of the N. E. course. Now connect the Current course to the center of the compass from which you set of the N. E. course. Measure this line for the Distance made good and run the rulers to the compass to find the Course Made Good from this same line.

See drawing No. 1.

EXAMPLES—Course boat sailed is S. E. ½ E. 32 miles. Current N. E. 9 miles during the time of running the course S. E. ½ E. Give the Course and Distance Made Good.

Ans. C. M. G. is N. 66° E. Distance M. G. is 34 miles. See drawing No. 2.

Mary sails S. S. W. for 30 miles in a current that has set and drift during her run of S. E. X. S. of 12 miles. Give C. D. M. G.

Ans. C. M. G. is S. 7° W. D. M. G. is 38 miles. See drawing No. 3.

The Jane runs S. W. 40 miles, and during the time she is in a current running W. N. W. with a drift of 12 miles. Give the C. D. M. G.

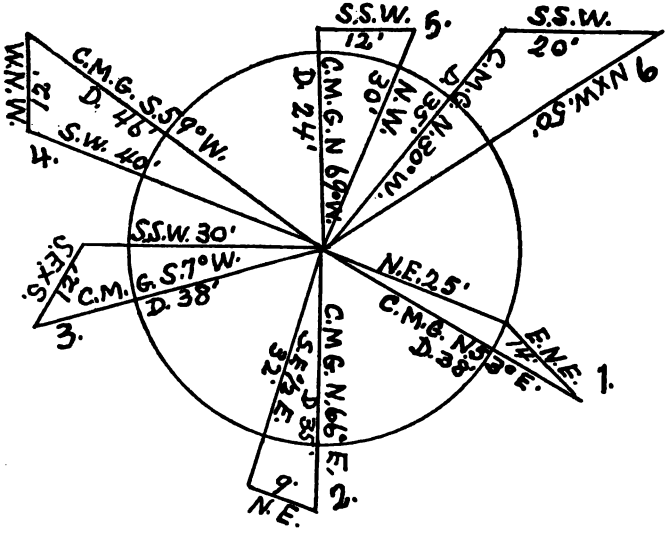
Ans. C. M. G. is S. 59° W. D. M. G. is 46 miles. See drawing No. 4.

Alhambra sails course true N. W. for 30 miles, and during the time she is in a current setting S. S. W. and drift of 12 miles during the time she sailed the course. Give the C. D. M. G.

Ans. C. M. G. is N. 69° W., and the D. M. G. is 24 miles. See drawing No. 5.

Admiral sails True Course N. X. W. for 50 miles and has a current running to the S. S. W. During her run of 50 miles the current has been calculated to be running 20 miles. Give the C. D. M. G.

Ans. C. M. G. is N. 30° W., the D. M. G. is 35 miles. See drawing No. 6.



FINDING COURSE TO STEER TO OFFSET CURRENT

If the Set and Drift of a current is known and we desire to steer for a certain port, light vessel or place, to offset that current or tide, we may find the proper course to steer by Inspection of the Traverse Table No. 2 of Bowditch and by plotting on the chart or paper for the purpose.

Wishing to know the course to steer so that the best advantage may be taken of a current, the course must be laid down on the chart TRUE. The distance to the port or lightship is measured and note made of it. The current is then calculated, and its Set and Drift is noted. BY TRAVERSE TABLES or BOWDITCH No. 1 or 2.

RULES—Find the angle between the Course to Port and the Current Set.

Find the number of miles that the Current will run while making the distance to the port. Use the Angle between Course to Port and Current Set as a COURSE and the number of miles the Current will run until Port is made as DISTANCE. Now find the Diff. Lat. and Dep. in the tables corresponding to COURSE AND DISTANCE.

Take the Distance to Port and the Dep. just found, and hunt the tables until you find them in line (not always exact to the tenth, you will find), and set down the Diff. Lat. for these two quantities. At the SAME TIME look at top or bottom of page for the COURSE and set it down. With this COURSE, apply the COURSE TO PORT, and remember that the amount is added or subtracted by finding out if Current is against you or with you.

Take the two DIFF. LATS. and add or subtract them for the RATE OF APPROACH of boat towards her Port in the number of hours it is supposed she will take to make Port.

EXAMPLES—Course to Port East, 90 miles. Cruiser making 9 knots per hour. Set of Current N. N. E. and Rate of Current 2 miles per hour. Give the Course to steer and the Rate of Approach towards her port.

NOTES—If cruiser is making 9 knots, it will take her 10 hours to reach Port.

If the Current is running 2 miles per hour, it will run in 10 hours (or the time the cruiser is in the Current), 20 miles.

Angle between Course to Port and Current is 6 points and run of Current 20 miles gives us in the Table No. 1 of Bowditch, Diff. Lat. 7.7 and Dep. 18.5.

Distance to Port 90 miles and this Dep. 18.5, now found in Table No. 2 of Bowditch, gives us Diff. Lat. 88.0 and at top of page COURSE 12°. This 12° is added to the Course to Port (East) for the proper STEERING COURSE. It is E. X. S., close enough.

The two Diff. Lats. 7.7 and 88.0 are added, as the Current is helping the cruiser and increasing her speed. It gives us 95.7 miles Rate of Approach towards the Port; or 9½ knots speed, instead of her 9 knots. She will then make Port ahead of her time by knowing this kink.

See drawing No. 1. All angles are taken from the circle which is supposed to be the compass rose of the chart. Instead of marking up the charts, you may draw a circle and set off the divisions for the courses needed. The Current lines may be used as a scale in drawing to measure the other lines.

EXAMPLE—Course to Lightship N. W. Distance 100 miles and speed of cruiser 10 knots per hour. Current running to the S. S. W. at 3 miles per hour. Give the proper course to steer and the rate per hour of the cruiser in this Current.

Ans. Steer N. N. W. ½ W. Rate of Approach towards Lightship is 84.5 miles in ten hours, or about 8½ knots speed of cruiser.

NOTES—Cruiser makes 10 knots and takes 10 hours to reach ship by calculation. She is then in Current during run, 30 knots.

Angle between N. W. and S. S. W. is 113° nearly. This used as Course and 30 tide knots as Distance give in table No. 2 Diff. Lat. 11.6 and Dep. 27.6. The Distance to L. S. 100 miles and this Dep. 27.6 give Diff. Lat. 96.1 and Course, at top of page 16°. Now add the 16° to the N. W. Course to find the proper course to steer to make the best of the Current.

The two Diff. Lats. are subtracted, as the Current is against the Cruiser and will cut her Rate of Approach towards the Lightship down to 84.5 for the distance sailed.

See drawing No. 2. All angles are laid off on their proper courses from the compass, TRUE.

EXAMPLE—Course to Buoy S. E. Dist., 48 miles. Speed of Cruiser, 6 knots. Current running to the S. W. with Drift of 2 miles per hour. Give the Steering Course to make the best of Current and the rate per hour the Cruiser will make under the conditions.

Ans. Angle between Course and Current 90°. This used as Course and time Cruiser will be in Current run, or 16 miles, give Diff. Lat. 0.0 and Dep. 16.0. As the Course is East or 90°, there is no Diff. of Lat. and the Dist. of 16 miles becomes the Dep.

Dist. 48 miles to Buoy and Dep. 16 give, in Table No. 2, a Diff. of Lat. 45.1 and Course, at top of page 20°. Subtract this 20° from the Course to Buoy for the Sailing Course, equals 115° or nearly, S. E. X. E. ¾ E.

The two Diff. Lats. subtracted give 45.1 miles for the Rate of Approach, or making speed of Cruiser come down to 5¾ knots per hour.

EXAMPLE—Course E. N. E. Distance to Fishing Grounds, 80 miles. Speed of Sloop with light fair wind is 5 knots. Current Set N. E. Drift of Current 2 miles per hour. Give the course to steer to get the best from the Current. Tell what time the Sloop will reach the Fishing Grounds.

Ans. Under the same condition until F. G. are reached, the Sloop will be acted upon by the Current for 32 miles of her trip.

Angle between Course to F. G. and Current Course is 2 points. With this Course, Table No. 1, and Dist. 32 miles, find the Diff. Lat. and Dep. 29.6 and 12.2.

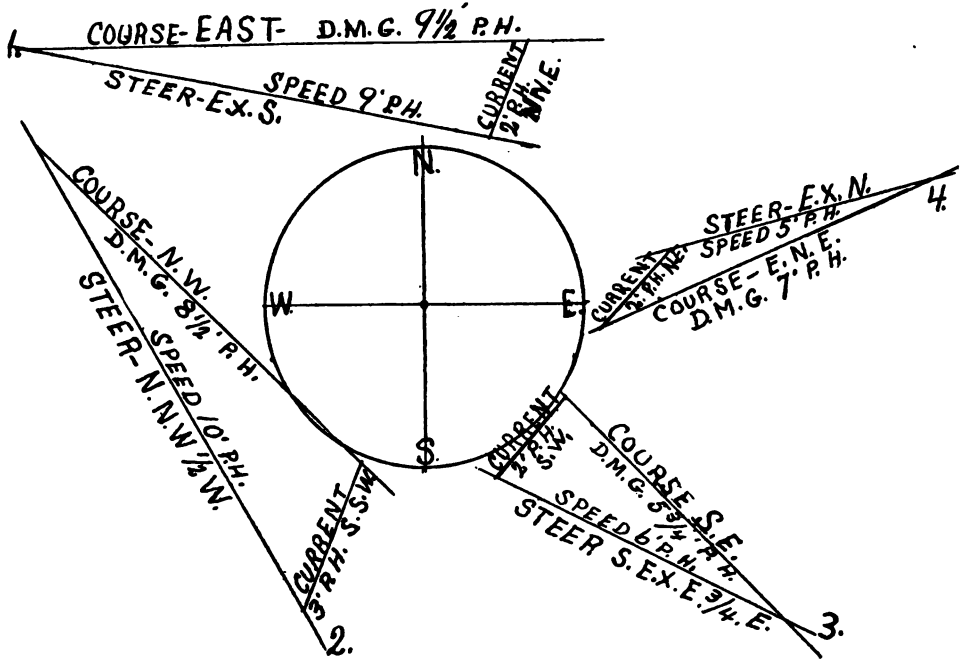
Dist. 80 miles and Dep. 12.2 give Diff. Lat. 79.0 and Course at top of page 9°.

E. N. E. Course and plus 9° gives Steering Course about E. N. E. ¾ E.

The two Diff. Lats. give 108.6 miles. This shows at once the Sloop is bettering her speed a lot. Instead of taking 16 hours to reach F. G. at 5 knots, the Sloop will reach there in about 11½ hours at nearly 7 knots speed.

REMEMBER that all courses are given and worked as TRUE COURSES. This applies to the Current Course. Only the Variation is taken into account with the Current Course.

See drawing No. 4.


COURSE-EAST- D.M.G. 9½ P.H.
STEER-E.x.S.
SPEED 9 P.H.
CURRENT 2 P.H. N.N.E.
1.
N.
W.
E.
S.
COURSE-N.W. D.M.G. 8¼ P.H.
STEER-N.N.W ½ W.
SPEED 10 P.H.
CURRENT 3 P.H. S.S.W.
2.
CURRENT 1½ P.H. S.W.
COURSE S.E. D.M.G. 5¾ P.H.
SPEED 6 P.H.
STEER S.E.x.E. ¾ E.
3.
STEER-E.x.N.
SPEED 5 P.H.
CURRENT 1½ P.H. N.E.
COURSE-E.N.E. D.M.G. 7 P.H.
4.

THE CHRONOMETER

THE CHRONOMETER

If you are lucky enough to have one of these Waltham Chronometers, you may work sights with accuracy and pleasure. They cost $75.00, but that's nothing if you are getting navigation down pat and really wish to practise the art. Remember that the Chronometer is set to Greenwich Mean Time and by knowing your Local Mean Time, you get the Longitude of your location.

After purchasing a Waltham Chronometer, you will have to find the Daily Rate by the following means; set your watch to the very second of the Chronometer; call up such firms as John E. Hand & Sons Co., Riggs Bros., Phila., or other places where they make a point of handling Chronometers and get the Chronometer time. The comparison of the time given and what your watch says, gives you the Slow or Fast of your Chronometer. Set this down on paper with date and hour that you made comparison.

Now to find out what the Chronometer is gaining or losing daily; call up again after ten days or more, and make another comparison. Be sure to call up the nautical instrument firm about the same hour you did the first time. The second comparison will give you ths Daily Rate of the instrument if you will divide the seconds, slow or fast, between the first and second comparison, by the number of days that have elapsed from the first to the second call.

Say the first comparison showed the Chronometer was slow 20 seconds and the second comparison showed it was 40 seconds slow and the days elapsed were twenty—then you would know the Chronometer was losing one second each day and the Daily Rate would be one second losing.

The author will be pleased to purchase a Waltham Chronometer for any of you and see to it that the instrument has a very small Daily Rate.

Address Dr. C. S. Street, 6037 Chestnut St., Phila., Pa.

THE CHRONOMETER

The Chronometer is a very fine timepiece, swung like a compass in gimbals, to keep it always face up and to prevent excessive motion to the works.

Yachtsmen may secure a fine Chronometer now at a price that does not break them. This instrument is made by the Waltham Watch Co. Agency in the ads.

A description of this timepiece shows a Chronometer that will be useful and one that may be depended upon.

DESCRIPTION—The Chronometer is provided with two extra long mainsprings, the winding crown winds both springs and the hands are set by the crown in the usual manner.

The movement is enclosed in a dust and weather proof case, with screw-back and bezel, and is suspended on gimbals to keep the movement always level and the dial up.

The Chronometer has a simple safe-locking device for holding the movement rigid when the Chronometer is carried.

The box has two covers or lids, one fitted with glass to protect the movement. The box is of mahogany, with brass mountings, and is very handsome. The instrument has fifteen jewels, compensating balance, balance pivot running on diamond, heavy dial with heavy hands and winding indicator, showing on dial when the Chronometer has run seven days.

Temperature affects the Chronometer, but it has a compensating device that takes care of changes; yet there is always a Daily Rate with Chronometers.

DAILY RATE—After a Chronometer is purchased, it has an Original Error, either fast or slow on a given Meridian. Usually the Meridian of Greenwich is used.

Now, if the Chronometer is losing 1 second daily, it has a Daily Rate of "One Second Losing." If it is gaining, the rate is called "Daily Rate Gaining."

WINDING—Wind the Chronometer at the same time every seven days. This keeps the same amount of spring in action and prevents a change of the rate. Do not take the Chronometer from its place, after screwing it down on the cruiser, until you must go out of commission. Wind until you come to the stop, but don't force the winding. The hands may be shifted to get the proper time should the timepiece run down.

Starting her up again, you may have to give the box a rotary motion.

Place the Chronometer where it will have the least motion on your cruisers and be out of the wet. If you must take the instrument off the boat, be sure to set the locking device, so that the movement will not swing and make the rate different.

Masses of iron near the instrument will cause change of rate, so will dynamo. Place the 12 hour in the position most suitable for comparison and keep the box in that place.

The author has one of these little beauties, and has taken many Chronometer Sights from it with accuracy. The instrument has been used in races and off-shore cruises, and has gone from boat to boat without change of rate; but you can bet a dollar the darling had the very best of care.

USING THE CHRONOMETER—The Chronometer is used to give you the Greenwich Mean Time and your watch gives you the Local Mean Time, and their difference is the Longitude you are in. As we do not take the Chronometer on deck, we must have a way to make a comparison of watch time with Chronometer Time.

The usual method is to take the difference between Watch Time and the Chronometer Time and call it C.-W. (Chronometer minus Watch), then, after the sight has been taken by the Watch Time, you add the C.-W., or difference, to the watch, and you have the Chronometer Time.

You may have to add twelve hours to the Chronometer Time, to make the subtraction possible.

As the Chronometer Time is generally calculated in twenty-four hours, you must see that this adding of twelve hours makes no change in the time.

EXAMPLES—C. T. 4h. 20m. 14s. W. T. 2h. 10m. 7s. subtracted, would give the Term C. minus Watch, 2h. 10m. 7s. Now two hours later, by the Watch Time, we would have W. T., 4h. 10m. 7s. Adding the Term, C. minus W. (2h. 10m. 7s.) we would have the C. T. of 6h. 20m. 14s.

Now take C. T. 10h. 50m. 40s. and W. T. 11h. 40m. 18s. we would have Term, C. minus W. 11h. 10m. 22s.

We have added twelve hours to the C. T. to make the subtraction possible. Now, three hours later the W. T. would be, 2h. 40m. 18s., and adding the C. minus W. it would give us, C. T. 14h. 50m. 40s.

QUESTIONS—C. T. 14h. 20m. 8s. and W. T. 2h. 10m. 4s. give the term, C. minus W. Ans. 12h. 10m. 4s.

C. T. 9h. 8m. 6s. and W. T. 11h. 22m. 4s. give the term, C. minus W. Ans. 9h. 46m. 2s. Give the C. T. two hours later. Ans. C. T. 11h. 8m. 6s.

C. T. 18h. 40m. 2s. and W. T. 4h. 20m. 2s. Give the term, C. minus W. Ans. 2h. 20m. 0s. Give the C. T. four hours later from the W. T. and term, C. minus W. Ans. W. T. 8h. 20m. 2s. plus C. minus W. gives C. T. that the face of the Chronometer would show, 10h. 40m. 2s., but calculated as a 24-hour timepiece, twelve hours would be added, making the C. T. 22h. 40m. 2s., which is exactly the same period.

ACCUMULATED ERROR—This means the accumulation of the seconds from one period to another. Say the Chronometer was gaining 2 seconds each day, then, in twenty days, we would have an Accumulated Error of 40s. fast.

If the Chronometer was losing one second each day, and we had an elapsed time of 45 days, we would have an Accumulated Error of 45 seconds, slow.

EXAMPLES—June 20th. Noon at Greenwich, the Chronometer was 1m. 18s. fast and gaining 1s. daily. What would be the Accumulated Error on June 30th? Ans. 10 seconds fast, and the Original Error of 1m. 18s. fast, would make the full error, 1m. 28s. fast.

Another Chronometer was put aboard the Cruiser May 4th, at Noon. It had an Original Error on April 10th of 3m. 40s. slow, but had changed its Daily Rate, since April 10, Greenwich Noon, to ½ second gaining daily. What would be the correction to the Chronometer when it came aboard? Ans. 3m. 23s. plus. The C. was slow, but gaining, yet still slow.

Just bought a Waltham Chronometer and found by the Rate Card that the instrument was gaining ¼ of a second daily on the G. M. T. June 12th, at Noon. What is the error of the Chronometer when I received it, August 19th, 7 A. M., in Long. 75° West?

Ans. Elapsed days 68 and gaining ¼s. daily, gives 17 seconds fast. The Long. 75° W. equals five hours, or 7 A. M. at place, while G. M. T. would be Noon, making the 68 days from Noon of June 12th to Noon of August 19th at Greenwich.

FINDING CHRONOMETER ERROR—All large cities have Time Balls that are dropped on a certain Meridian Time. On the East coast of North America we generally use the 75° Meridian, or five hours in time, difference between Greenwich and the cities. Philadelphia drops a Time Ball from the Bourse Building at Noon, on 75 Meridian Time. This ball may be seen down river about Kaighns Point Ferries, but the large buildings have closed it out for up-river sight.

Now if we wish to find the error of a Chronometer from a Time Ball, we watch the fall of the ball and note the instant. Then mark down 0h. 0m. 0s. or Noon, and add the Longitude, or five hours, making M. T. at G. 5h. 0m. 0s. Now set the C. T. under and take their difference, which will show the error of the instrument.

EXAMPLE—Having the correct time by my watch, I compared it with the Chronometer when my watch said 11 A. M. and the C. T. was 4h. 2m. 0s. Working the rule to secure C. minus W., I find the difference is C.—W. 5h. 2m. 0s. I keep my eye open a few minutes before Noon for the dropping of the Time Ball, and snap my stopwatch at the instant and make comparisons.

Here is the way—Set down W. T. or 0h. 0m. 0s. and add the C.—W. or 5h. 2m. 0s., which shows the time the Chronometer will be. Now, as the Longitude is 5 hours W., add this to the W. T., making five hours, and set the C. T. under it, and then subtract them. This gives the correction to the Chronometer of 2 minutes fast. If we wish to secure the error from a sight by the Long. problem, to secure the Hour Angle, which is the Apparent Time at place or ship, we must find the Declination, Polar Distance and know the Latitude.

It is best to work this problem from the Artificial Horizon. After securing the H. A. or L. A. T., it must be corrected by the amount of Equation of Time, to turn it into L. M. T. Then the Long. is added to the L. M. T. for the G. M. T., if Long. is West, but subtracted if East. Under the G. M. T. is placed the C. T. and the difference noted, for the error of Chronometer.

EXAMPLE—June 6th, P. M. at ship, in Lat. 39° 58′ 02″ N. and Long., by chart, 75° W. Lying at anchor and wishing to know the error of my new Waltham Chronometer, I took Time Sight for Hour Angle, using my Chronometer Time, after corrections, supposed to be right, had been applied.

C. T. of sight, 10h. 1m. 20s. corrected. Cor. Eq. of T. is 1m. 8s. minus. to M. T. Give the C. error.

Ans.—Secured H. A. or L. A. T. from the problem and turned it into L. M. T. by subtracting the Cor. Eq. T., giving me L. M. T. 5h. 0m. 53s. Now adding the Long. 75° or 5 hrs., gives me the G. M. T. that the Chronometer should show. The C. T. at sight was 10h. 1m. 20s. and the G. M. T. shows a difference of 27 seconds, that the Chronometer was fast.

GREENWICH DATE BY CHRONOMETER—Don't forget that a Greenwich Date must be had for all examples in navigation. It is always expressed in the Astronomical form of Time.

EXAMPLES—C. T. showing 2 hours, might be G. D. 2 hours from Noon, the commencement of a certain day, and it might be 14 hours of the same date. G. M. T., from the face of the Chronometer, might show 2h. 40m. 40s. A. M. of a certain date and would be 14h. 40m. 40s. from the Noon before. Getting the G. D. from the Chronometer, you are at a loss to know if you should add 12 hours to what the face shows.

APPROXIMATE G. D.—Set down the Date at ship or place, and use the Long. by D. R.; adding when the Long is W. and subtracting when it is E.

EXAMPLES—April 1st, 3h. 46m. 0s. P. M. Long. 90° East, subtracted from ship Date, gives G. D. Ans. 90° E. Long. equals in time 6 hrs. subtracted from the L. M. T. gives us March 31d. 21h. 46m. 0s. Approx. G. D. You see, we have added 24 hours to the L. M. T. to make the subtraction possible, but the Date has been set one day back.

May 10d. 7h. 40m. 20s. A. M. at ship, would be expressed in Astron. form May 9d. 7h. 40m. 20s. Long. W. 64° 55′ 0″ W., added to the L. M. T. would give the Approximate G. D. of May 10d. 0h. 0m. 0s.

CORRECT G. D. BY CHRONOMETER—Find the Approximate G. D. and apply the C. Error.

EXAMPLES—June 10th, about 4h. 40m. P. M. on board the Cruiser. Long. by D. R. 48° W. The C. T. was 7h. 50m. 20s. and slow on G. M. T. 4m. 20s. Give the correct G. D.

Ans. As the time is P. M. the hours, minutes and seconds are Astron. Time, of the same date. The Cruiser's Date and the Long. W. added, give the Approx. G. D. The correction to the C. T. gives the Cor. G. D. of June 10d. 7h. 54m. 40s.

Aug. 10th, about 8h. 50m. A. M. on board the "Admiral" in Long. 134° W. C. T. was 6h. 0m. 10s. and fast on G. M. T. 4m. 11s. Give the Cor. G. D.

Ans. Date on "Admiral" expressed in Astron. T. gives us Aug. 9d. 20h. 50m. and the Long., in time, 8h. 56m., added to the L. M. T. gives us 29h. 46m.; so we drop 24 hours and give the Date one day ahead, making the Approx. G. D. Aug. 10d. 5h. 46m. The C. T. corrected, gives us Correct G. D. Aug. 10d. 5h. 55m. 59s.

L. M. T. Sept. 6d. 4h. 42m. P. M. Long. 127° E. C. T. 8h. 0m. 30s. and fast on G. M. T. 3m. 2s. Give the Cor. G. D.

Ans. L. M. T. minus the Long. in time of 8h. 28m. gives the Approx. G. D. Sept. 5d. 20h. 14m. C. T. corrected, gives 7h. 57m. 28s. Now, this does not touch the Approx. G. D., so the 12 hours must be added, for the Cor. G. D., making it Sept. 5d. 19h. 57m. 28s.

Oct. 1st, L. M. T. 8h. 10m. A. M. in Long. 45° W. The C. T. was 11h. 5m. 49s. and slow on G. M. T. 6m. 4s. Give the Cor. G. D.

Ans. Turn the L. M. T. into Astron. Time by adding 12 hours. Add the Long. in time, 3 hours, gives the Approx. G. D. Sept. 30d. 23h. 10m. The C. T. corrected, gives C. T. 11h. 11m. 53s. and, as it does not touch the Approx. G. D., we add 12 hours, making it the Cor. G. D. Sept. 30d. 23h. 11m. 53s.

The Greenwich Date is used to find the Declination, Equation of Time, the M. S. R. A., Greenwich Apparent Time, Greenwich Sidereal Time, and the Longitude, when taken in connection with the Hour Angle.

DOPE ON LATITUDE BY THE POLE STAR

The N. A. for the year gives a method of working for the Latitude by an Observation of Polaris (the North Star) and it gives the Latitude within a mile. In the 1917 almanac, all that is required is to find the L. S. T. and take out the correction to the True Altitude and apply it as the signs state.

EXAMPLE—L. S. T. 14h. 20m. 0s. Correction from N. A. plus 1° 6′ 18″ to the True Alt., which is 39° 40′ 00″. The Lat. is 40° 46′ 18″ N.

As the rules for the Lat. by Polaris change in the N. A., it is best to know another method to work same for the Lat.

RULES—Find the L. S. T. This is done by knowing your Long. and correct L. M. T. If in E. Long. subtract the Long. by D. R. from the L. M. T., and if in W. Long. add the L. M. T. for the G. M. T. This gives you the G. D. to correct the M. S. R. A., or use the Chronometer Time.

Take out the M. S. R. A. from the N. A. and correct it for the number of hours in the G. D. Then add it to the L. M. T. for the L. S. T. Now find the Right Ascension of Polaris for the Date, and subtract it from the L. S. T. This gives you the Hour Angle of the star. If it is over 12 hours, subtract it from 24 hours and reverse the name of the H. A. Now turn this H. A. into arc. Meaning, to turn the hours, minutes and seconds of time into degrees, minutes and seconds of arc. Methods given in this book.

POLARIS DECLINATION—Find the Declination of Polaris in the N. A. and subtract it from 90° to get the Polar Distance, as it is called. Turn this P. D. into minutes by multiplying the degrees by 60 and adding the minutes. Then express the quantity as a decimal. Like this—say you had P. D. 1° 8′ 57″, it would be 68.9′. Find the log. of this quantity and be sure you use the three figures when taking out the log. In this case, the number would be called 689 and the log. would be 1.83822. The Index would be 1., as you had but 2 full figures in your number.

Find the Cosine of the Hour Angle and add it to the log. of the P. D. or 68.9′, and keep the last number of the Index only. Now find this log. in Table No. 42 Bowditch, and the natural number will give 69 nearly. Turn this into arc by subtracting 60 from it and calling it 1° and 9′. This is to be added to the True Altitude of the star for the Latitude. The Lat. is within a mile of being correct by this method, but may be nearly correct, if the Altitude is measured when the star is near the Meridian Passage. This may be found from the N. A. under the heading "Meridian Transit of Stars." The time is given for the Meridian of Greenwich. Little diff. at your Meridian.

EXAMPLE—From the Obs. Alt. of Polaris the True Alt. is 29° 5′ 55″. C. T., corrected, 13h. 39m. 04s. The M. S. R. A., corrected, is 5h. 17m. 14s. The Long., turned into time, is 5h. 25m. 42s. The Long., subtracted from the C. T. and the M. S. R. A. added to the remainder, gives the L. S. T. Polaris Declination, 88° 51′ 03″ N., and its R. A. is 1h. 28m. 39s., both taken from N. A. Give the Lat.

ANSWER—L. S. T. 13h. 30m. 36s. R. A. of Polaris 1h. 28m. 39s. the H. A. is 12h. 01m. 57s. W. Follow the rule and turn the H. A. into E. by subtracting from 24 hrs. gives us H. A. 11h. 58m. 03s. E. Turn this into Arc. Equals 179° 30′ 45″. Find the Cosine of this quantity and set it down. Now dig up the Declination of Polaris, which is 88° 51′ 03″ N. Subtracted from 90° gives us 1° 08′ 57″, which, by the rule, is to be turned into minutes of arc. It equals 68.9′. Find the log. of this quantity, which is 1.83822, to be added to the other log. This gives us 1.83820, and when found in Table No. 42 of Bowditch, we have 69 nearly, in the first column, which is to be turned into arc. It equals for the correction of the True Altitude, 1° 9′ 00″, giving us the Lat. from our True Alt., which is 29° 5′ 55″, North Latitude 30° 15′ 55″.

NOTES ON G. S. T. AND L. S. T. FOR LONGITUDE

HOUR ANGLE AND RIGHT ASCENSION—After the G. S. T. has been calculated, then the Hour Angle is found from the Tables No. 44 Bowditch. The Hour Angle, the Star or Planet's Right Ascension, subtracted one from the other, gives the L. S. T. for this method. The subtraction is only done when the star or planet is EAST of the Meridian. When WEST of the Meridian, the Hour Angle and Right Ascension are added to get the L. S. T.

Put the L. S. T. under the G. S. T. and subtract for the Longitude in Time. This quantity must then be turned into arc. If the G. S. T. is least the Long. is East and if West the Long. is West.

SIDEREAL TIME BY THE MOON—Don't forget to put down the Date, as sometimes we have the G. S. T. less if the Date is not considered. That is, the Date might show a full day ahead of the L. S. T.

EXAMPLES—G. S. T. May 2d. 10h. 40m. 48s. and L. S. T. May 2d. 6h. 40m. 50s. Long. in T. is 3h. 59m. 58s. or 59° 59′ 58″ W. as the G. S. T. is best.

June 4d. 5h. 50.50s. G. S. T. and L. S. T. June 3d. 20h. 40m. 40s. Long. in T. is 9h. 10m. 10s. Long. 137° 32′ 30″ W.

Dec. 2d. 20h. 23m. 19s. G. S. T. and the L. S. T. is Dec. 3d. 1h. 21m. 55s. The Long. in T. is 4h. 58m. 36s. East as the G. S. T. is least. Notice the Dates.

ADDING H. A. AND R. A.—Hour Angle West, 2h. 20m. 30s. and star's R. A. 4h. 20m. 20s. gives L. S. T. 6h. 40m. 50s.

H. A. 20h. 40.10s. West Star's R. A. 10h. 13m. 42s. L. S. T. is 30h. 53m. 52s. Cut off 24 hrs. and make them 6 hrs. This does not displace the star.

SUBTRACTING THE H. A. AND R. A.—Hour Angle East, 2h. 20m. 30s. R. A. 4h. 20m. 30s. L. S. T. is 2h. 0m. 0s.

G. S. T. 6h. 04m. 12s. and H. A. 9h. 20m. 12s. E.—R. A. of star is 2h. 08m. 06s. Sub. gives L. S. T. 7h. 12m. 06s. gives Long. in time, 1h. 07m. 54s. Long. 16° 58′ 30″ E.

FINDING L. M. T. FROM L. S. T.—Find the L. S. T. by rules given, then subtract the M. S. R. A. *from* the L. S. T. to get L. M. T. Add 24 hrs. to the L. S. T. if necessary to make the subtraction.

EXAMPLES—L. S. T. 12h. 16m. 20s. M. S. R. A. corrected, 17h. 56m. 44s. gives L. M. T. 18h. 19m. 36s. L. S. T. 6h. 09m. 37s. M. S. R. A. corrected, 2h. 04m. 30s. gives L. M. T. 4h. 05m. 07s.

GIVE THE L. M. T. July 2nd, A. M. aboard Cruiser. C. T. July 2d. 3h. 20m. 02s. H. A. of Arcturus West of the Meridian was 2h. 20m. 10s. W. M. S. R. A. corrected is 6h. 40m. 22s. R. A. of Arcturus is 14h. 11m. 56s. Give the L. M. T.

Answer—R. A. and the H. A. added, gives L. S. T. and the M. S. R. A., subtracted from L. S. T., gives L. M. T. July 2d. 9h. 51m. 44s. P. M.

Aug. 4th, P. M. at sea. The C. T. was Aug. 4d. 14h. 20m. 30s. H. A. of star Vega was 1h. 28m. 20s. E. of the Meridian. M. S. R. A. corrected, 8h. 52m. 12s. Vega's R. A. 18h. 34m. 11s. Give the L. M. T.

Answer—H. A. subtracted from the R. A. of Vega gives L. S. T., as the H. A. is East. M. S. R. A., subtracted from the L. S. T., gives Aug. 4d. 8h. 13m. 39s. P. M. as the L. M. T.

Long. by D. R. 75° W. The C. T. showed Dec. 25d. 13h. 10m. 20s. Sirus R. A. was 6h. 41m. 34s. and her H. A. was 4h. 20m. 10s. E. The M. S. R. A. corrected, is 18h. 14m. 14s. Give the L. M. T. and the Date and Time of the star on the Meridian.

Answer—H. A. of the star sub, from the R. A. gives L. S. T., and the M. S. R. A. subtracted from the L. S. T. gives Dec. 25d. 8h. 07m. 10s. L. M. T. in the evening.

Star's H. A. added to the L. M. T. gives the time the star will be on the Meridian, as the star was East. Vega on the Meridian Dec. 26d. 12h. 27m. 20s. A. M.

Another way—Subtract the corrected M. S. R. A. from the star's Right Ascension even if you must add 24 hrs. to the star's R. A. to make the subtraction. Ans. Gives the same time.

VISIBILITY OF STARS—With Lat. of place and Dec. of star of same names and the Declination of star greater than the Co-Lat. (Co-Lat. = 90° minus Lat.) the stars are never below the Horizon.

EXAMPLE—Lat. 40° N. Co-Lat. 50° and Dec. of stars N. Give some stars that are never below the Horizon.

Answer—Caph, Dec. 58° N. Ruchbah, Dec. 59° N. Polaris, Dec. 88° N. Alioth, Dec. 56° N. Mizar, Dec. 55° N. Kochab, Dec. 74° N.

LAT. AND DEC. OF DIFFERENT NAMES—If the Declination of the star is greater than the Co-Lat., the star is never above the Horizon of the place.

EXAMPLES—Lat. 42° N. Dec. of the stars S. Co-Lat. 48°. Give the stars that are not above the Horizon.

Answer—Acherner, Dec. 57° S. Canopus, Dec. 52° S. Miaplacidus, Dec. 69° S. Acrux, Dec. 62° S.

IDENTIFICATION OF STARS—Is there a way to find the name of a star not known?

Answer—Yes. By the Star Identification Tables gotten out by the Government.

RULES—Find the L. S. T. by adding the M. S. R. A. corrected, for the G. D. to the L. M. T. Enter the Identification Tables with the Lat. of place, the measured Altitude corrected, to True Alt. and the star's Azimuth secured by Compass bearing (Compass bearing must be True bearing), and find the star's Declination and Hour Angle.

Turn the found Hour Angle into R. A. by subtracting it from the L. S. T., if the star is West. If the star is East of the Meridian, add it to the L. S. T. for star's R. A.

The Declination, as found from the Tables and the calculated R. A., are now looked for in the Nautical Almanac, and where they compare nearest, gives the name of the star.

Example—Lat. 36° N. and Long. 60° W. Feb. 26th, off shore. L. M. T. 6h. 20m. R. M. Measured the Altitude of an unknown star, and worked up the True Altitude to 31° 30′ 00″. True bearing of the star was 285° (subtract from 360° for the tables). What is the name of the star?

WORK.—M. S. R. A. 22h. 23m. 00s., corrected for G. D. gives the L. S. T. Entering the Identification Tables with the Lat. 36°, True Alt. 32° and Azimuth 75°, we find Declination 28° 30′ and H. A. 4h. 38m. W. Subtract this H. A. from the L. S. T. for the star's R. A., which gives star's R. A. 0h. 5m. We have now found star's R. A. 0h. 5m., and from the Tables, the Declination 28° 30′. In the Nautical Almanac will be found the star "Androm" with R. A. 0h. 4m. 6s. and Declination 28° 38′ 6″ N. This surely is the star.

You must take out the quantities nearest to the Identification Tables. As this method is merely used to secure the names of stars, you may be as much as 2° off, but the Altitude should be calculated correctly, if it is to be used for the Lat. or Long. problems.

PLANETS—They cannot be worked by the Identification Tables. You may secure the Latitude and Longitude by them, however.

EXAMPLES—Obs. Alt. 51° 20′ 24″ S. Cor. for H. E. 15 ft. 4′ 37° minus. Long. at time of sight 75° W. or 5 hrs. Mer. Pas. 3h. 58m. Cor. Dec. 10° 58′ 07″ N.

Answer—True Alt. from 90° gives Z. D. or 38° 44′ 13″ N. Dec. added to Z. D. gives Lat. 49° 42′ 20″ N.

MERIDIAN PASSAGE—In the example just given, it will be noticed that the Planet could not be seen at Mer. Pass. or 3h. 58m. P. M. To know if a Planet may be seen from inspection of the N. A., it must be remembered that the Meridian Passage of the Planet is given in Astronomical Time.

If it is 15h. 30m., it is 3.30 A. M., and if 4h. 50m. 20s., it is that time P. M. By looking over these times in the N. A. you will be able to know which planet may be seen on the Meridian.

EXAMPLE—Oct. 10th, 1917, A. M. at ship in Lat. by D. R. 36° 20′ 30″ N. Long. 60° W. Obs. Alt. of Jupiter on the Meridian, 74° 51′ 40″ S. H. I. 15 ft. Give Lat.

Answer—Mer. Pass. of Jupiter, 15h. 27m. 00s., or 3h. 27m. A. M. A slight correction for the time would give 40s. plus for Mer. Pass. at place. Dec. from N. A., no corrections, 21° 15′ 06″ N. Cor. for Alt. 4′ 4″ minus. Lat. 36° 27′ 30″ N. Pax. in Alt. about 1″.

The Planets may be worked for Long. by securing the time of sight, Alt. and H. A.

MIDDLE LATITUDE AND MERCATOR SAILING

REMARKS—Middle Latitude may be used if the Lats. are of different names and the distance small. Then the Dep. may be assumed equal to the Diff. Long. Should the Dist. be large then each track must be calculated separately.

With Middle Lat. Sailing, it is assumed we sail the mean of the Lats. as a parallel. This works out all right for short distances, but for long cruises or runs, the Mercator Sailing is the better.

NEW TABLE—A table has been constructed to give a more accurate Middle Latitude. The Diff. Lat. is found at top of page of the Table and the Middle Lat. is found in first column. The correction to the Middle Lat. is minus where marked so and plus in the blank spaces. This table makes the Middle Latitude Sailing nearly as accurate as the Mercator Sailing. When there is a large Diff. Long. and a small Diff. Lat. the Middle Lat. Sailing is the better to use. This means a Course nearly East or West.

The Diff. Long. found by Mid. Lat. is true at the Equator. In high Lats. when the Course is oblique and the Dist. large, the error becomes considerable.

You may divide the Dist. into small portions at that, and get a correct answer.

The Diff. Long. secured by Mid. Lat. Sailing is generally too small. If we have a Course N. E. and a Diff. Lat. of 500 miles and the Course sailed below 30° N. the Diff. Long. will have an error of 2′. If sailed between 40° and 50° there will be an error of 3′ and between 60° and 70° an error of 19′.

A COMPARISON—Give the Course and Distance from Lat. 34° 20′ S. Long. 18° 22′ E. to Lat. 15° 50′ S. Long. 5° 45′ W. Want the answer by Middle Lat. Method, both by Inspection of Traverse Table No. 2 and Calculation. Also, want answer by Mercator Method, both by Inspection and Calculation.

RULES—Middle Lat. Method by Inspection: Find the difference between the Lats. and Longs. in miles. Find the Midle Lat. and use the nearest degree as Course and find the Diff. Long. in the Dist. colm. so that the Diff. Lat. colm. directly opposite will show you the Departure. Now with the Diff. of Lat. of the two places and this Dep. just found, corresponding as nearly as possible in their respective columns, we find at the bottom of the page, the True Course, and where they correspond, will be found in the Dist. colmn. the Dist.

NOTE—As the quantities are too large for the tables you must divide by 10. This is easily done by setting the decimal point one place from the last figure toward the left. BUT don't forget to multiply the Dist. by 10 when you find it.

MIDDLE LAT. METHOD BY CALCULATION—Find the Diff. Lat. between the two places. Find the Diff. Long. also. Find the Middle Latitude and correct it by the New Table. Hunt up the log. of the Diff. Long. and be sure to give the proper Index or 3. as the number has four figures or 1447 miles. Find the Cosine of the Middle Lat. and add the two logs.

Now find, in Table No. 42, the log. of the Diff. Lat. of the two places and subtract from the two logs. This gives you 10.07201. Find the Course corresponding to the Tangent of this number. This gives us the True Course between the two places. Now for the Distance.

DISTANCE—Take the log. of the Diff. Lat. of the two places and find the Secant of the True Course just found and add them. (Drop the 10. index of the Sec.) Now dig up the log. of the sum just found in Table No. 42 for the Distance.

REMEMBER—You look for the number in the first column and find the first three figures and then go across page until you see the next figure at top of page, to get the log. Finding the number corresponding to the log. Find the log., as near as possible and take the number from the first column, and also the number at top of page, for the last figure. This stands good for this example, as the index is 3. and the number must have four figures.

BY MERCATOR METHOD—Rules: To find by Inspection the Course and Distance between the two places.

Find the Diff. Lat. and Long. as before.

Take from Table No. 3 of Bowditch the Meridional Parts for the TWO Lats. and as they are of same name subtract them and call the remainder Mer. Diff. Lat. Now with this quantity and the Diff. Long. look them up in the Table No. 2. Mer. Diff. Lat. in the Lat. column and the Diff. Long. in the Dep. column. At the bottom of the page will be the True Course, 50°. Using this course just found, find the Diff. Lat. between

the two places (1110 miles) in the Lat. column and in the Dist. column is the required Dist.

REMEMBER—The quantities are too large as before, so place the decimal point and then multiply the distance by 10 for the required Dist.

BY MERCATOR METHOD AND CALCULATION—Find the log. of the Diff. Long. and add 10. to the index, making 13. for the index in this example, as we have four figures in the number.

Find the log. of the Mer. Diff. Lat. and subtract the two logs. Gives us 10.07163. Now find the Course corresponding to the Tangent of this number. Gives 49° 42′.

Take the log. of the Diff. Lat. between the two places and the Course just found, in the Secant column of Table 44, and add the two logs. Now find the number corresponding to the sum of the logs. for the Distance between the two places. Gives 1716 miles.

ANSWERS—Middle Latitude Method by Inspection gives True Course N. 50° W. and Dist. 1720 miles.

By Calculation, the True Course is N. 49° 44′ W. and Distance 1717 miles.

BY MERCATOR Method and Inspection—True Course N. 50° W. and Dist. 1720 miles.

By Calculation, the True Course is N. 49° 42′ W. and Dist. 1716 miles.

The four examples show but a small difference between them and the True Course shows as much as 18′ difference. This might be worth something on a long voyage, but the checking of the Dead Reckoning by the sights would take care of that small difference, as the course would be changed several times, more than likely, on so long a run.

EXAMPLES—Sailed True W. S. W. for 768 miles from Lat. 2° 5′ N. and Long. 22° 30′ W. Give the Lat. and Long. in. Give the True Course and Distance to Lat. 2° 15′ S. and Long. 43° 38′ W. Inspection by Mercator Method.

Answer—Course 6 pts. and Dist. 768 give Diff. Lat. 287.6 S. Lat. in 2° 43′ S. Meridional Parts for the two Lats. are added to get the Mer. Diff. Lat. equals 286.2. The Course 6 pts. and Mer. Diff. Lat. Dep. 690.3, which is the Diff. Long. Long. in, 34° 00′ 18″ W.

Lat. left and Lat. to, give Diff. Lat. of 28′ and the Mer. Diff. Lat. of the two Lats. gives 28.1. The Diff. Long. in miles is 878. Comparison of Mer. Diff. Lat. and Diff. Long. close as possible, give Course N. 87° W. and Dist. 576 miles.

Sailed N. W. X. W. 229 miles from Lat. 52° 6′ N. and Long. 35° 6′ N. Give the Lat. and Long. arrived at by Inspection from the Mercator Method.

Answer—Course 5 pts. and Dist. 229′ give Diff. Lat. 127.2. The Lat. in is 54° 13′ 12″ N. The Mer. Parts for the two Lats. is subtracted. Same Course and the Mer. Diff. Lat. compared in the tables give Dep. 317.6 = the Diff. of Long. W. Long. in is 40° 23′ 36″ W.

NEW TABLE

Mid. Lat.	*Difference of latitude.*															Mid. Lat.
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	12°	14°	16°	18°	20°	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
15	−86	−85	−84	−83	−81	−79	−76	−73	−69	−65	−56	−46	−34	−21	− 6	15
18	−67	−67	−66	−65	−63	−61	−59	−56	−53	−50	−43	−34	−23	−12	1	18
21	−54	−54	−53	−52	−51	−49	−47	−44	−42	−39	−32	−24	−15	− 5	7	21
24	−44	−44	−44	−42	−41	−40	−38	−36	−33	−31	−24	−17	− 8	1	12	24
30	−31	−30	−29	−29	−28	−26	−24	−23	−20	−18	−12	− 6	1	11	21	30
35	−23	−22	−21	−21	−19	−18	−17	−15	−12	−10	− 5	2	10	18	28	35
40	−17	−16	−15	−14	−13	−12	−10	− 8	− 6	− 4	2	8	16	25	34	40
45	−12	−11	−11	−10	− 8	− 7	− 5	− 3	− 1	1	7	14	22	31	41	45
50	− 8	− 8	− 7	− 6	− 5	− 3	− 1	1	3	6	12	20	28	38	49	50
55	− 5	− 5	− 4	− 3	− 2	0	2	5	7	10	17	25	35	46	58	55
58	− 4	− 3	− 3	− 1	0	2	4	7	10	13	20	29	39	51	64	58
60	− 3	− 3	− 2	− 1	1	3	5	8	11	14	22	32	43	55	69	60
62	− 3	− 2	− 1	0	2	4	7	9	13	17	25	35	46	60	75	62
64	− 2	− 1	0	1	3	5	8	11	14	18	27	38	50	65	81	64
66	− 2	− 1	0	2	4	6	9	12	16	20	30	42	55	71	89	66
68	− 1	0	1	2	5	7	10	14	18	22	33	46	61	78	98	68
70	− 1	0	1	3	5	8	12	16	20	25	37	51	67	87	109	70
72	0	0	2	4	6	10	13	18	23	28	41	57	76	97	123	72

[a] The statement often made that the latitude of conversion is always greater than the middle latitude is not correct when the compression of the earth is taken into account, as an inspection of the table will show; that statement is based upon an assumption that the earth is a perfect sphere, and it was upon that assumption that a table which appeared in early editions of this work was computed. The value of the compression adopted for this table is $\frac{1}{293.465}$.

THE TRAVERSE FORM

COURSE	QUAD.	DIST.	DIFF. LAT.		DEP.	
			N.	S.	E.	W.
154°	S.E.	8	---	7.2	3.5	---
68°	N.E.	23	8.6	---	21.3	---
298°	N.W.	36	16.9	---	---	31.8
82°	N.E,	48	6.7	---	47.5	---
309°	N.W.	46	28.9	---	---	35.7
			61.1	7.2	72.3	67.5
			7.2		67.5	
			53.9		4.8	

This form is drawn out to make possible the collection of the Diff. Lat. and Dep. on the several courses run with their proper distances set down.

After the sailing courses are corrected to True Courses from the 360° card, they are set down in the Traverse Form with their proper Quadrants. The Distance now follows and then it becomes time to look up the Bowditch Tables No. 2 for the Difference of Latitude and Departure on each of these True Courses corresponding to the Distance run.

The first Course, 154°, is found in the brackets of the table and opposite 8 miles or the Distance Column, is found the Diff. Lat. and Dep. They are set down under the letters S. and E. as the 154° is taken from the South East Quadrant. The other True Courses are treated the same way.

ADDING DIFF. LAT. AND DEP.—Now add up the four columns separately. Subtract the Departures one from the other. Subtract the Diff. Lat. one from the other. We then have the True Diff. Lat. and Dep. for the five True Course as follows: Diff. Lat. N. 53.9 and Dep. E. 4.8.

COURSE AND DISTANCE MADE GOOD—Now you must hunt the same table until you find the Diff. Lat. and the Dep. opposite each other for the Course and Distance Made Good after sailing all the five True Courses. It must be remembered you cannot always find the Diff. Lat. and Dep. exactly. Our example shows from the table Course N. 5° E. and Dis. 54 miles Made Good.

In setting down these quantities in the Traverse Form, try to remember that when a True Course is given as North or South, there is no Departure, and you must set down the distance of the run as Diff Lat.

When a True Course is given as East or West there is no Diff. Lat., so you must set down in the Traverse Form the distance on that course as Departure. Be sure you set it down in the correct column.

DEPARTURE—Say we had a True Course East with distance sailed 40 miles. The heading E. must be looked for in the Traverse Form, and the 40 miles placed in line with the course, and under the E. column.

DIFF. LAT.—If we had sailed True South 60 miles. The distance would be put down under S. Column and in line with the course.

This is part of Dead Reckoning and should be taken up in every form for those who sail yachts off shore, as time after time the course is changed and every course must be taken into account to get the True Course and Distance Made Good, after a certain number of hours' sail.

In this example we have a Diff. Lat. which is N. 53.9 miles. Now if we had been in Lat. 40° N. and had sailed this Diff. Lat. further North, we would be in a higher Lat. or 40° 53′ 54″ N. The .9 is nine-tenths of a mile or 54″.

DIFF. LONG.—The Departure in the example shows that we have sailed also to the Eastward 4.8 Dep. miles. Now we must find out our Long. Say we had been in Long. 72° W. before sailing the five courses, then we must hunt up the Middle Latitude so that we may know the Diff. Long.

MIDDLE LATITUDE—Add the Lat. Left and the Lat. In and divide by 2 to get the Mid. Lat. In our example we had Lat. Left 40° N. and Lat. In, or Arrived at, 40° 53′ 54″. Added and divided by 2 gives us 40° 26′ 57″ as the Mid. Lat. Now use 41° as a course in table 2 of our Bowditch and find the Dep. (4.8) in the (Lat. column) and in the Dist. column will be found the Diff. of Long. which is 6 miles as Diff. of Long. Apply this to the Long. Left, 72° W., and remember you took the Dep. from the E. column, so the Diff. Long. is East or subtracted from Long. Left. Gives us Long. In 71° 54′ 00″ W.

There are many of like problems, but this case will be enough to work from.

The Middle Lat. used as a course would have made little difference if we had used 40° instead of 41°.

SWINGING THE CRUISER TO FIND THE COMPASS DEVIATION

The easiest way to find out about how much the compass is off on the eight principal points is to swing ship on the four Cardinal and the four Inter Cardinal Points.

The method is easy, but it takes a little time. First, you must find the Magnetic Bearing of some distant object that is on the chart. The object should be at least five or six miles from the place your are going to try out the work.

Suppose you were down the bay and the day was clear, then you could see one of the lighthouses for seven or eight miles, and knowing your position at the time of swinging ship, you could plot the Magnetic Bearing from the chart.

To make this clear. Let's say the cruiser had just rounded a well-known point, or had just come abeam of another light, a distance of six or seven miles away from the light, up bay or river. Surely, you can lay off the Mag. bearing from the lower to the upper light.

Set this bearing down on the paper and then start the ship ahead, slowly, on the Compass Course N. Keep her on that course until you find, now, how the light bears, then set down columns of Ship Headings and Compass Bearings. Set the point you are heading, say N., under the first column and the bearing of the light under the second column.

Now, swing the cruiser on the Compass Course E. and find what the bearing is, then set it down. Do this on the S. and W. Compass Points and set down the new bearings.

Swing her on the four Inter Cardinal Points and set down the bearings as before.

EXAMPLE—Found from the chart that Cross Ledge Light bore Magnetic, from my known position, N. 68° E. On my Comp. Course N. found the light bore N. 74° E.

RULE—Subtract the two bearings and the remainder will be the Deviation of the compass on the point the cruiser was heading, at the time the bearings were taken. In this case, the difference is 6° Deviation.

NAMING THE DEVIATION—If the Magnetic Bearing is to the right of the Compass Bearing, the Deviation is East, and if the Magnetic Bearing of the light is to the left of the Compass Bearing, the Deviation is West. In our little example the Deviation is 6° W., as the Magnetic Bearing is to the left of the Compass Bearing.

EXAMPLES—Abeam of Fourteen Foot Bank Light House. Found that Brandywine Light House lay S. E. Magnetic, from the inside Compass Rose on the chart. Swung the cruiser on the four Cardinal Points for Deviation.

Heading N. the Comp. Bear of Brandywine was S. E. ¼ E. Devi. ¼ E.
Heading E. the Comp. Bear. of Brandywine was S. E. ¼ S. Devi. ¼ W.
Heading S. the Comp. Bear. of Brandywine was S. E. ½ E. Devi. ½ E.
Heading W. the Comp. Bear. of Brandywine was S. E. ¼ S. Devi. ¼ W.

Suppose I wished to sail the Magnetic Courses N. E. S. W. by my Compass, what would I steer to be correct?

Ans. Magnetic Course N. Compass Course N. ¼ W.
Magnetic Course E. Compass Course E. ¼ S.
Magnetic Course S. Compass Course S. ½ E.
Magnetic Course W. Compass Course W. ¼ N.

LEAVING SHORE ON A CRUISE OR TAKING THE DEPARTURE

When going out of sight of land it is usual to take a Departure and set down the opposite bearing as the first course. Say the bunch left old Overfalls Light Vessel bound for a fun-trip off shore to practice navigation. The old packet bears N. W. 3 miles distance. Enter this in the opposite course or S. E. and set down the Distance as 3 miles.

If you know the Lat. and Long. of a place left, you may set that down as the Departure. The Departure may be found in other ways—the sailing along the land for a while and using the Two and Four Point Bearing method will give a good Departure. Another way is to plot the run from a given point until a certain light or buoy bears in a certain direction and then finding the Distance from the light or buoy, setting the course to leave the land and let her rip.

EXAMPLES—No. 1. Sailing Southerly for 30 miles, we left old Five Fathom Bank Light Vessel over our stern until we had Fenwicks Shoals Light Vessel bearing True N. 48° W. From the chart we find that the bearing from Five Fathom to Fenwicks is S. 24° W. and the Distance between the two old hookers is 22½ miles. Give the Distance we are from Fenwicks Shoals Light Vessel after sailing the 30 miles Southerly, and the True Course we made good from Five Fathom Bank Light Vessel.

Ans. Cruiser is 14 miles from Fenwicks when it bore True N. 48° W., and the True Course sailed was S. 2° E.

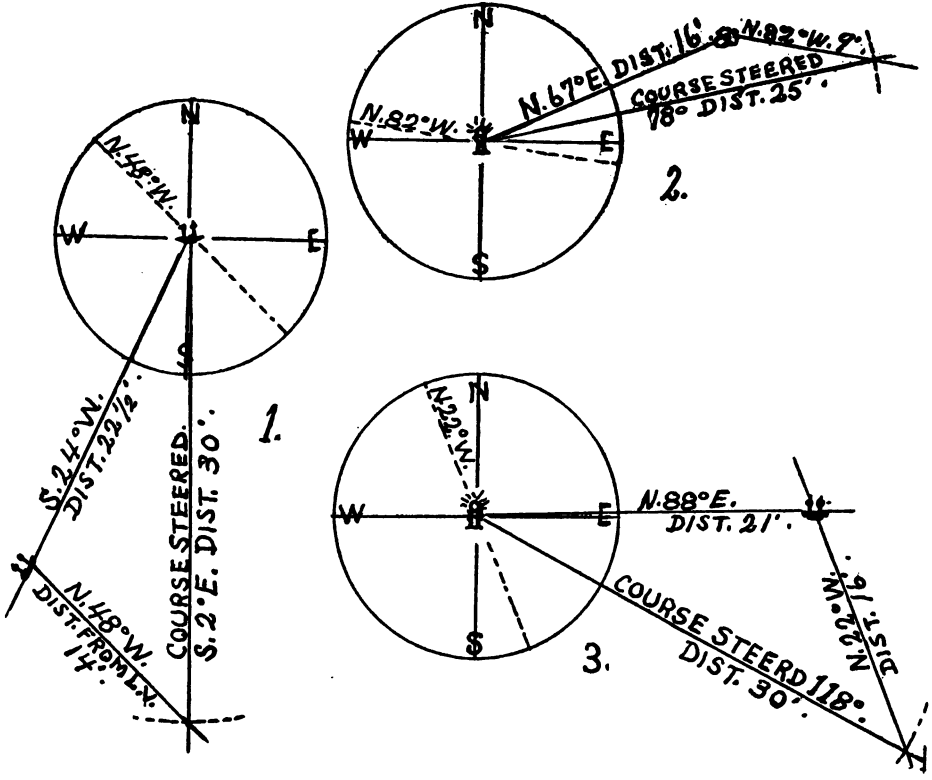
How do we find this out? Ans. Draw a circle on the summer chart or use the Compass Rose of the sailing chart and lay off from center of circle or Compass Rose the True bearing from Five Fathom to Fenwicks (S. 24° W.), and make a dot at the Distance between them (Dist. 22½ miles). Now lay off the Bearing, True, after sailing the 30 miles (bearing N. 48° W.). Now take the dividers from the center of the Compass Rose or the circle, and measure on the chart 30 miles with them, and then sweep the Bearing Line or N. 48° W. until the other leg of the dividers cross the Bearing Line. Make a mark and measure the Distance from the mark to the Fenwicks Light Vessel. The crossing of the lines will show the True Course sailed if you take the parallel rulers and find the arc from the line sailed from the center of the circle or Compass Rose. See drawing No. 1.

No. 2. Left Mantauk Point Light over the stern and sailed Easterly for 25 miles. I had Block Island Light bearing then, N. 82° W. From the chart, I find the bearing from Mantauk Light to Block Island is N. 67° E. and the Dist. between the lights is 16 miles. Give the Distance from Block Island Light, after sailing the 25 miles, and give the True Course made good.

Ans. Dist. from Block Island Light to position of Cruiser is 9 miles, and the True Course made good is Course 78°. See drawing No. 2.

No. 3. Leaving Chincoteague Inlet, I had Assateague Light over the stern and sailed South Easterly for 30 miles. I then had Winter Quarters Shoals Light Vessel bearing True N. 22° W. From the chart, I find that Winter Quarters Shoals Light Vessel bears from Assateague, True, E. 2° N., and the Dist. between the two lights is 21 miles. Give the Distance of the Cruiser from Winter Quarters Light Vessel and the True Course steered.

Ans. True Course steered 118° and the Dist. from Winter Quarters Shoals Light Vessel is 16 miles. See drawing No. 3.


N
W
E
S
N.48°W.
S.24°W.
DIST. 22½'.
COURSE STEERED.
S.2°E. DIST. 30'.
N.48°W.
DIST. FROM L.K.
14'.
1.
N.82°W.
N.67°E DIST. 16'.
N.82°W. 9'.
COURSE STEERED
78° DIST. 25'.
2.
N.22°W.
N.88°E.
DIST. 21'.
COURSE STEERD 118°.
DIST. 30'.
N.22°W.
DIST. 12'.
3.

THE SEXTANT AND ITS ADJUSTMENTS

The SEXTANT is the most valuable nautical instrument on shipboard. With it we may measure the angle between two objects. These measurements are sufficiently accurate for navigation, but not so accurate as a fixed instrument which is used on shore.

The form of the Sextant is shown in the cut, with letters to show the different parts. The frame is made of the brass and the Arc, AA, is of silver and marked in divisions from 10′ to 60′ and then to degrees up to 140°.

A, the Arc or Limb; B, Tangent Screw; C, Set Screw; E, the Telescope; F, Tube for colored glasses; H, handle; I, Inverting Telescope; K, Ring to hold Telescope; M, Index Mirror; m, Horizon Mirror; P, Shade Glasses for Index Mirror; Q, Shade Glasses for Horizon Mirror; R, Reading Glass to read the Arc and Vernier marks; S, Pivot for Reading Glass Arm to turn on.

The Index Bar is pivoted at the centre of the Index Mirror. On the lower end of this bar is the Vernier, or small scale, to make the readings of the Arc of proper quantity.

The VERNIER allows of reading much smaller divisions, and with it an accurate measurement between the Horizon and the Sun may be taken. It may be read to 10″. The Vernier is placed on the lower end of the Index Bar, below the Index Mirror, M, and travels along the Arc, which allows of readings of the Arc when the glass is inclined.

The HANDLE, H, is for holding the instrument, and should you have a chance to sight through an old seadog's Sextant, be sure that you take hold of the Handle, and not the brass work.

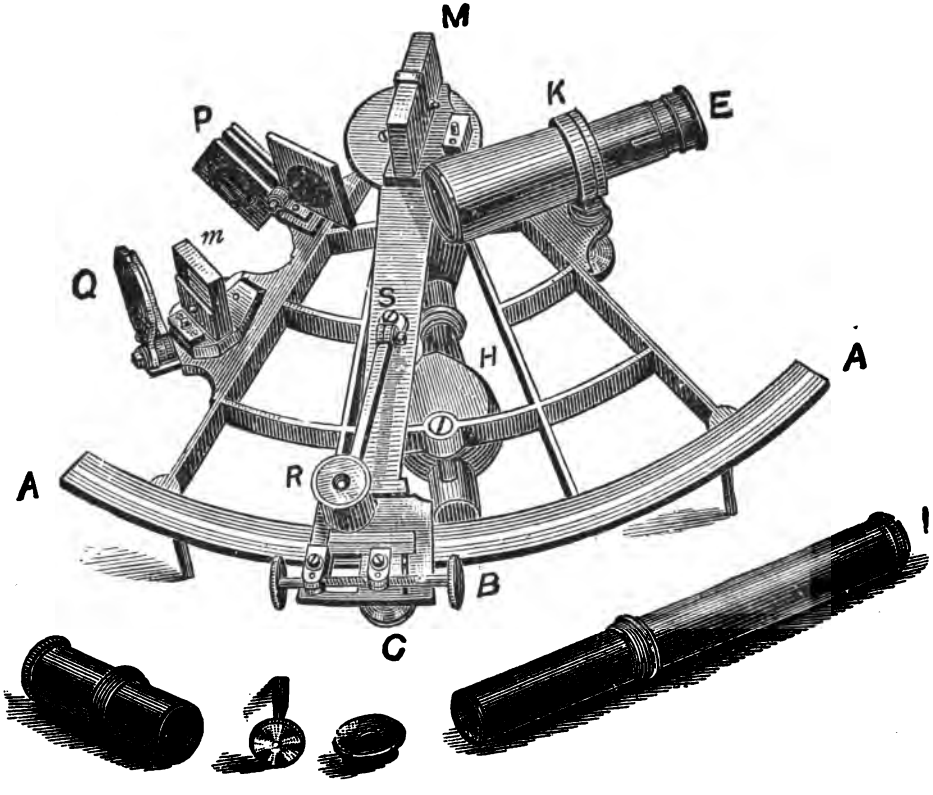
The INDEX MIRROR, M, is of plate glass and silvered and moves with the Index Arm.

The HORIZON MIRROR, m, is the same, but has part of the glass left plain to allow of seeing the Horizon direct.

The HORIZON MIRROR is also called the HORIZON GLASS.

The TELESCOPE, E, is placed in the RING, K, to make the objects observed more distinct. The observations may be taken without the Telescope by fixing the eye very close to the RING.

The READING GLASS, R, is attached to the Index Bar by the PIVOT, S, making the reading of the very fine lines easily seen.


M
P
K
E
m
Q
S
H
A
A
R
I
B
C

The COLORED GLASSES, P and Q, are different shades to allow of sighting brilliant Celestial objects without hurting the eye.

The TANGENT SCREW, B, is fixed to the Index Bar for more accurate adjustment than by hand.

The SET SCREW, C, is to hold the Tangent Screw in place while working it. When the Index Bar is to be run quite a distance along the Arc, this Set Screw is loosened.

All Sextants are fitted with Verniers, which contain one more division than the length of the scale of the Arc.

SCALE readings and VERNIER readings increase towards the left hand.

READING the Sextant—Observe the INDEX or Diamond-shaped mark and read the Arc to the nearest ten minutes and then consult the Vernier where the lines are straight from Arc to across the face of the Vernier and note the extra minutes and seconds. Add these to what you had on the Arc for the full reading of the Altitude.

ADJUSTMENTS OF THE SEXTANT—The two surfaces of each mirror and shade glass must be parallel planes.

The Arc must be a plane, and its graduations, as well as those of the Vernier, must be exact.

The axis must be at the center of the limb, and perpendicular to the plane thereof.

The Index and Horizon glasses must be perpendicular, and the line of sight parallel to the plane of the limb.

The PERMANENT ADJUSTMENTS are all but the last one given, and are made by the maker of the instrument.

ADJUSTMENT OF THE INDEX MIRROR consists in making the reflecting surface of this mirror truly perpendicular to the plane of the Sextant.

TEST—Set the INDEX near the middle of the Arc, place the eye in the plane of the instrument and CLOSE to the Index Mirror. NOTICE whether the direct image of the Arc and its reflected image form a continuous Arc. Instrument is correct.

If REFLECTED image drops, the glass leans backward.

If REFLECTED image seems to rise, the glass leans forward. The adjustment is made by the screws at the back of the mirror.

ADJUSTMENT OF THE HORIZON MIRROR—Make the reflecting surface of this mirror perpendicular to the plane of the Sextant.

TEST—Set the Telescope and look toward a star, move the Index Arm until the Reflected image passes the Direct image. If they pass directly over each other the mirrors are parallel. If one passes the other to either side the Horizon Glass or Mirror must be adjusted by the set screws.

ADJUSTMENT BY THE SEA HORIZON of the Horizon Mirror—Hold the Sextant Vertical, bring the direct and reflected images of the Horizon Line into coincidence; incline the Sextant until its plane makes but a small angle with the Horizon. If the images coincide the glasses are parallel. If not, the Horizon Glass must be adjusted.

ADJUSTMENT OF THE TELESCOPE—The line of sight or the AXIS of the Telescope must be parallel to the plane of the Sextant.

TEST—Set the Telescope with the two wires in it parallel with the plane of the Sextant, select two objects not closer than 90° apart, bring the reflected image of one of the objects directly in coincidence with the direct image of the other at the inner wire. Now make the objects appear on the other wire by slightly moving the instrument. If the contact is perfect, the instrument is correct as far as the Axis is concerned. If the objects seem to overlap at the wire, the Telescope is not parallel and must be adjusted by the screws. Repeat this several times until the objects are the same on both wires.

ERRORS OF SHADE GLASSES may be noted by measuring angles with and without the glasses and noting their difference.

INDEX ERROR of a Sextant is the error of its indications, due to the fact that when the Index and Horizon Mirrors are parallel the Zero of the Vernier does not coincide with the Zero of the Arc. It is necessary to find that point of the Arc at which the Zero of the Vernier falls when the two mirrors are parallel. If this point is to the left of Zero of the Arc or limb, all readings will be too great, and if to the right they will be too small.

The INDEX ERROR may be found by measuring the diameter of the Sun. Bring the upper limb of the reflected image to touch the lower limb of the direct image, and then bring the lower limb of the reflected image to touch the upper limb of the direct image. Mark the readings when on the Arc, NEGATIVE, and when off the Arc, POSITIVE. The Index Correction is one-half the algebraic sum of the two readings.

EXAMPLE—

On the Arc	−	40′	20″	−	31′ 20″
Off the Arc	+	30′	10″	+	33′ 10″
2)	−	10	10	+	1 50
Index Error	−	5	5	+	0 55

Now that we have our Sextant adjusted and the Index Error known, let's take an Observed Altitude of the Sun and read it off from the Arc of the Sextant and the Vernier.

The OBSERVATION—Set the eyeglasses to suit the eye, hold the Sextant with right hand, grasp the Set Screw with left hand and move the Index Bar to the front of the Sextant; see that the Sun is in the Index Mirror and then reflected to the Horizon Mirror. Now "bring the Sun down," as it is called. To do this you must move the Sextant downward as you move the Index Arm forward. Just as soon as the lower edge of the Sun is on the Horizon—stop. Lock the Index Arm by setting the screw.

READING THE ARC—Squint through the reading glass and notice that you have the Arrow or Index of the Vernier just beyond 70°. It looks like 70° and 5′, but it is not. Look at the marks on the Vernier past 4′ until you see the lines of the Arc and the Vernier exactly as one line. This will show you that the reading is 70° 4′ 40″, the OBSERVED ALTITUDE.

The MARKS on the Arc of the Sextant run from 0 degrees to 120 degrees, and measurements may be taken up to that number of degrees with such an instrument. Remember a Sextant is one-sixth of a circle.

0 degree first mark, and then comes 5° and then 10° and then 15° and so on.

Each SPACE of FIVE degrees is marked in degrees, making five equal divisions between 0 degree and the next number which is 5 degrees.

Each DEGREE is again divided into six equal parts, making each one of these divisions TEN MINUTES. You must see, then, that the Arc is capable of giving but 10′ as its lowest reading.

The VERNIER gives the next lowest reading to complete the angles secured from Horizon to Sun. This little scale moves alongside of the fixed scale of the Arc, so that you may measure any part of the small division of TEN MINUTES.

The Vernier is marked with MINUTES from 2 on to 10, and each TWO MINUTES are divided into twelve equal parts, and half of these, SIX, has a longer line to show you it is ONE MINUTE. Now, every minute is marked into six equal parts, which are, of course, 10″ each.

Let's try the angle again. 70° on the Arc is easily understood, as the arrow is just a little past that number of degrees. The Vernier shows a straight line with the Arc, FOUR lines from the figure 4 on the Vernier. This means that you have the four minutes and some seconds to add to your reading from the Arc or 70°. Each line means 10″ (ten seconds of Arc) to be added, so you have forty seconds with the four minutes, from the reading of the Vernier. Try it.

Now that we have the OBSERVED ALTITUDE it would be great if that was all there was to it. But we must get the TRUE ALTITUDE, which is the Altitude of a Heavenly body's center as it would be measured by an observer at the center of the earth, above the plane passed through the center of the earth at right angles to the direction of the Zenith. To get this dope we must find the quantities of the following corrections: INDEX ERROR, DIP, REFRACTION, PARALLAX and SEMIDIAMETER.

INDEX ERROR is a correction of the Sextant after it has had the mirrors adjusted. It is either a minus or plus number of minutes and seconds of arc to be applied to the Observed Altitude.

REFRACTION—The rays of light from a Heavenly body must pass through the atmosphere before they come to the eve of the fellow who is taking the sight with his Sextant. This atmosphere is not uniform and is more dense near the earth's surface. This causes the rays of light to make a concave curve. This shoots the observed body above where it should be by observations. There is a correction to be made to the Observed Altitude for this Refraction and you get it from Table 20-A, Bowditch. Remember it is subtracted from the Altitude. In the Altitude we have from the Sextant 70° 4′ 40″. You would look in Table 20-A and find only the 70° with 21″ to be subtracted from the Altitude.

TABLE 20-B of Bowditch gives you the Refraction and Parallax combined, and that table is the best to use, as it saves you applying two quantities.

DIP is the short word used for the angle of depression of the Visible Horizon below the True Horizon.

CAUSE—It is due to the elevation of the observer's eye above the level of the sea.

HEIGHT OF EYE is also called DIP. This means that you do not see the Horizon on the sea level, but see it around the corner, as it were.

TABLE 14 BOWDITCH gives the correction for the number of feet you are above sea level for DIP, and it is always subtracted from the Observed Altitude.

NOTES—The higher you take the observation, the more correct the table 14 for DIP will be. The warm water of the Gulf Stream and cooler atmosphere will make the DIP more than the table. From high winds to less the DIP will increase. From low to high wind, DIP will decrease. When the sea water is colder than the atmosphere, the Visible Horizon is raised and the DIP is decreased.

PARALLAX is the difference between the position of a Heavenly body, as seen at the same instant from the center of the earth and from a point on its surface.

Parallax is less as the bodies are further from the earth. This is the reason NO Parallax is considered when sighting stars.

Table 16 BOWDITCH gives the Parallax corrections for the Altitude, and it is added to the Altitude when using table 16, but when combined with table 20-B the table gives minus quantities.

SEMIDIAMETER is half the angle subtended by the diameter of the visible disk at the eye of the observer. It is found in the Nautical Almanac for each day.

Semidiameter varies with the distance; thus the Semidiameter of the Sun varies each day of the year as the earth is further or nearer the Sun.

ADD the Semidiameter to the Observed Altitude when you bring the lower limb of the Sun down to the Horizon. Subtract it when the upper limb is brought to the Horizon.

TABLE 46 BOWDITCH gives all Altitude Corrections for Sun and Stars.

Be sure you correct the amount by the small table under for the Month and Day of Month.

NO Correction from this lower table when finding the correction for stars.

TAKING SIGHTS FROM A SHORE HORIZON

Many times the men who are taking up navigation and have sextants, wish to try sights while at their clubs or when cruising down the bay. This may be done even when the land is directly under the Sun.

Take the Altitude and correct it from the little Table for the DIP. The amount is to be subtracted from the Observed Altitude. You then apply the other quantities the same as before, for correction of the Observed Altitude.

The Table gives the estimated distance from the shore to the line of water marking the Shore Horizon. The upper figures give the Feet above the Water, and the other figures are the amounts that are to be subtracted. Just try it out and see how near you come to the Latitude or Longitude after working up the problems.

Don't use this Table for correction of DIP when the Sea Horizon is used.

DIP means the height of the eye above the sea level.

DIP OF THE SHORE HORIZON.

Miles	Height of eye in feet from the water.					
	5	10	15	20	25	30
¼	11'	23'	34'	45'	57'	68'
½	6	12	17	23	28	34
¾	4	8	12	15	19	23
1	3	6	9	12	15	17
1¼	3	5	7	10	12	14
1½	3	4	6	8	10	12
2	2	4	5	7	8	9
2½	2	3	4	6	7	8
3	2	3	4	5	6	7
3½	2	3	4	5	6	6
4	2	3	4	5	5	6
5	2	3	4	4	5	6
6	2	3	4	4	5	6

MISCELLANEOUS PROBLEMS

Star's R. A. 11h. 24m. 54s. and H. A. 5h. 15m. 17s. E. The M. S. R. A. 2h. 4m. 30s. Give the L. S. T. and L. M. T. Answer—L. S. T. 6h. 9m. 37s. L. M. T. 4h. 5m. 3s.

Pollux R. A. 7h. 40m. 16s. and M. S. R. A. 0h. 26m. 36s. Give the Mer. Pass. Answer—7h. 13m. 40s.

Ordered to steer 120° True for 26 miles, from North East End Light Vessel, then to lay course True 340° for 40 miles, sight Atlantic City, N. J., and lay next course True 30° for 75 miles; then to steer East True, for 13 miles and report to Fire Island Lightship.

Lay the Courses and Distances on the chart. Give the Course and Distance Made Good by Traverse Form. Answer—N. 33° E. Dist. 107 miles.

Lat. and Long. of N. E. End L. V. 38° 57′ 45″ N. 74° 29′ 34″ W. Give, from the Traverse Form and Middle Lat. Method, the Lat. and Long. arrived at. Answer—Lat. in, 40° 27′ 21″ N. and Long. in, 73° 12′ 34″ W.

G. S. T. 5h. 59m. 48s. and L. S. T. 1h. 59m. 50s. Give the Long. in Time. Answer—3h. 59m. 58s. W.

Obs. Alt. from Art. Horz. 89° 17′ 0″ Sun bearing S. I. E. 1′ 20″ minus, Cor. to the Alt. plus 15′ 8″. Cor. Dec. 5° 9′ 0″. Give the Lat. Answer—39° 58′ 2″ N. Lat.

Give the Right Ascension and Declination of the following stars for June: Arcturus, Spica, Rigel, Sirus, Vega, Procyon, Aldebaran and Dubhe. Answer—Found in N. A.

Give Lat. by the Single Alt. and Time problem, from the following: L. A. T. 2h. 49m. 7s. Cor. Dec. 5° 15′ 24″ S. True Alt. 30° 30′ 31″. Answer—39° 46′ 43″ N. Lat.

G. S. T. 2d. 20h. 23m. 19s. Give the Long. by Observation of the planet Jupiter. True Alt. 27° 23′ 12″. Lat. by D. R. 34° 42′ 0″ S. Declination of planet, 18° 50′ 56″ S. and R. A. 20h. 45m. 3s. The H. A. is West. Answer—74° 39′ 0″ E. Long.

Lat. 8° 58′ 0″ N. Long. by D. R. 60° 30′ 0″ E. True Alt. of the star Regulus, 30° 30′ 12″ East of the Meridian. C. C. T. 3h. 10m. 36s. Star's Dec. 12° 22′ 12″ N. and its R. A. 10h. 4m. 0s. M. S. R. A. corrected, 22h. 43m. 48s. Give the Long. Answer—61° 50′ 15″ E.

Had the C. T. and Obs. Alt. of the star Aldebaran, E. of the Meridian, for Long. The True Alt. 28° 55′ 53″ Lat. by D. R. 46° 20′ 0″ N. C. T. 13h. 37m. 40s., but slow on G. M. T. 1m. 21s. The M. S. R. A., corrected, 12h. 28m. 59s. Dec. of the star 16° 20′ 48″ N. and R. A. 4h. 31m. 14s. Give the Long. Answer—29° 10′ 24″ W.

The following data is secured from the last example: L. A. T. 4h. 19m. 54s. Lat. 46° 20′ 0″ N. Decrease 16° 20′ 48″ N. True Altitude 28° 55′ 53″. Give the Calculated Altitude by the St. Hilaire Method. Answer—28° 56′ 15″ Cal. Alt. The Alt. Diff. is 0° 0′ 22″ away from the Sun.

Lat. and Long. left, Nantucket Light Vessel, 40° 37′ 02″ N. 69° 37′ 06″ W.

Sailed Course 353° and Dist. 176 miles. Give the place arrived at by Inspection, using Mercator Method. Answer—Lat. in, 43° 31′ 44″ N. Long. in, 70° 5′ 36″ W.

Lat. of Nantucket L. V. 40° 37′ 02″ N. Lat. of Portland L. V. 43° 31′ 30″ N.

Long. of Nantucket L. V. 69° 37′ 06″ W. Long. of Portland L. V. 70° 05′ 38″ W.

Give the Course and Distance between the two places by Mercator Method by Calculation. Answer—Course 357°. Dist. 174 miles.

Lay off the two problems on the chart and make comparison and give the difference.

Find the True Course and Distance between the two places by the Traverse Table No. 2

From Sandy Hook L. S. in Lat. 40° 28′ N. Long. 73° 50′ W. to
St. Davids, Bermuda, Lat. 32° 22′ N. Long. 65° 31′ W.
Answer—True Course S. 39° E. Dist. 636 miles.

From Barnegat Lt. House, Lat. 39° 46′ N. Long. 74° 06′ W. to
Block Island Lt. House, Lat. 41° 09′ N. Long. 71° 33′ W.
Answer—True Course N. 55° E. Dist. 144 miles.

From 5 Fat. Lt. Ship, Lat. 38° 47′ N. Long. 74° 34′ W. to
Diamond Shoals, Lat. 35° 05′ N. Long. 75° 18′ W.
Answer—True Course S. 9° W. Dist. 225 miles.

RULES—Find the Diff. Lat. between the two places, the Diff. Long. and the Middle Lat. Use the Middle Lat. as a Course in Table 2 of Bowditch and the Diff. Long. in the Distance Column. The Departure is found in the Lat. column.

With this Dep. just found, and the Diff. Lat. compare in table 2 for the Course and Distance.

Give the distance of light from observer—Height of light from chart, 240 feet. Height of eye from mast-head, 90 feet. Answer—Dist. of light from observer, 28.7 miles.

Running down channel and wanting to take my departure from a known light, at 2 P. M. I observe it bearing from me N. X. W. After sailing W. X. N. ¼ N. at 8 knots per hour, at 3.30 P. M. it bore from me N. N. E. ½ E. Give the distance from the light at time of second bearing.

Answer—17.1 miles.

Being off the Dumplings, I ran 34 miles on a direct course between south and west, and then observed Cape Pope bearing from me S. X. E. ½ E. Cape Pope bears from the Dumplings S. X. W. ¾ W. Dist. 43 miles. Give the course steered and the distance from Pope.

Answer—Ship's course was S. 32° W. Distance from Cape Pope 12.17 miles.

Cruising between two small islands, I find the first bears from me S. W. X. W. ¾ W. and the second E. S. E. After running S. X. W. ½ W. for 15 miles, the first bore from me N. W. X. W. and the second E. ½ N. Give the bearings and distance between the islands.

Answer—The first island bore from the second N. 84° 28′ W. and the second from the first S. 84° 28′ E., and their distance was 42.49 miles.

Two cruisers, A and B, sail from the same place, C; A sails N. E. X. N. 84 miles, and B sails S. E. 76 miles. Give their bearings and distance from each other.

Answer—Bearing of A from B is N. 3° 16′ 30″ W. of B from A is 3° 16′ 30″ E. and their distance is 123.8 miles.

Being off the coast in Lat. 47° 04′ 30″ S. and Long. 65° 26′ W. I found the true bearing of a cape to be W. 20° S., and after running S. 12° 30′ W. for 32 miles, the cape bore N. 34° W. Give the Lat. and Long. of the cape.

Answer—Lat. 47° 12′ 42″ S. Long. 65° 59′ W.

Cruiser left Lat. 34° 24′ S. Long. 173° 10′ E. and sails True West until she arrives in Long. 163° 35′ E. Give the distance run.

Answer—474.4 miles.

Cruiser in Lat. 32° 22′ N. Long. 52° 20′ W., sails West 365 miles. Give her distance from Bermuda in the same Lat. and Long. 64° 43′ W.

Answer—Distance from Bermuda 262.6 miles.

In what parallel of Lat. is the Departure one-third the Diff. of Long.?

Answer—In Lat. 70° 32′.

At what rate per hour is Greenwich Observatory, in Lat. 51° 28′ 38″ N. carried around the earth's axis?

Answer—560.54 geographical miles per hour.

Give the True Azimuth and Deviation from the following examples and data.

Lat. 4° N. True Dec. 11° N. Apparent T. 4 P. M. Vari. 8° W. Comp. Azi. N. 80° 36′ W.

Answer—True Azi. N. 79° 36′ W. Devi. 7° W.

Lat. 16° N. Dec. 14° N. A. T. 9 A. M. Vari. 10° E. Comp. Azi. N. 70° 23′ E.

Answer—True Azi. N. 86° 23′ E. Devi. 6° E.

Lat. 24° N. Dec. 22° N. A. T. 11 A. M. Vari. 12° W. Comp. Azi. N. 83° 15′ E.
Answer—True Azi. N. 95° 15′ E. Devi. 0° 0′.
Lat. 32° N. Dec. 12° N. A. T. 4 P. M. Vari. 8° E. Comp. Azi. N. 87° 35′ W.
Answer—True Azi. N. 95° 35′ W. Devi. 4° E.
Lat. 5° S. Dec. 15° N. A. T. 10 A. M. Vari. 6° E. Comp. Azi. S. 120° 24′ E.
Answer—True Azi. S. 124° 24′ E. Devi. 10° W.
Lat. 45° S. Dec. 8° N. A. T. 4 P. M. Vari. 10° W. Comp. Azi. N. 50° 23′ W.
Answer—True Azi. S. 117° 37′ W. Devi. 2° W.
Lat. 53° S. Dec. 22° N. A. T. 9 A. M. Vari. 6° W. Comp. Azi. N. 49° 12′ E.
Answer—True Azi. S. 138° 48′ E. Devi. 2° W.

BERMUDA DEAD RECKONING

Left Ambrose Channel Light Vessel. Lat. 40° 28′ N. Long. 73° 50′ W. bearing by compass N. N. W. Distance 9 miles. Cruiser heading S. S. E. This heading must be corrected for Leeway, Devi. and Vari. from the second course, and set down in the Traverse Form, as the first Course.

Second Course S. S. E. 28k. wind E. X. S. L.Way ½ pt. Devi. 4° W. Variation for the courses all the same for the first day's work, Vari. 8° W.

Course S. S. E. 32k. wind E. X. S. 0 L.Way, Devi. 4° W.
Course S. E. X. S. 24k. wind E. L.Way, 1 pt. Devi. 5° W.
Course S. E. X. S. 20k. wind E. L.Way, 1½ pts. Devi. 5° W.
Course E. N. E. 12k. wind S. E. L.Way, 2 pts. Devi. 6° W.
Course E. ½ N. 8k. wind S. S. E. L.Way 3½ pts. Devi. 7° W.

Change these courses into Arc and form a Traverse Table to secure the Diff. Lat. and Dep. Then find, by Middle Latitude Sailing, the Lat. and Long. IN.

Answer—Lat. IN, 39° 09′ 42″ N. Long. IN, 72° 19′ 00″ W. From this position, sailed the following courses:

Course E. ½ N. 15k. wind S. S. E. L.Way 3 pts. Devi. 7° W. Vari. 8° W.
Course S. ½ W. 2k. wind E. S. E. L.Way 2½ pts. Devi. 0. Vari. 8° W.
Course S. X. E. 7k. wind E. X. S. L.Way 2 pts. Devi. 1° W. Vari. 8° W.
Course S. E. X. S. 46k. wind N. W. L.Way 0. Devi. 3° W. Vari. 8° W.

Current set South, Magnetic, for 12 miles. Vari. 8° W.

Change the courses to Arc and secure the Lat. and Long. IN, from the same method as before.

Answer—Lat. IN, 38° 7′ 12″ N. Long. IN, 71° 32′ 0″ W. From this position, sailed the following Course, S. S. E. ¾ E. 21k. free wind. Devi. 3° W. Vari. 9° W. Give the Lat. and Long. IN, as before.

Answer—Lat. IN, 35° 27′ 48″ N. Long. IN, 68° 26′ 0″ W. Sailed from this position the following courses:

Course S. E. 41k. wind S. S. W. L.Way ½ pt. Devi. 4° W. Vari. 8° W.
Course S. E. ½ S. 44k. wind S. S. W. L.Way ¾ pt. Devi. 3° W. Vari. 8° W.
Course S. E. X. S. 40k. wind S. W. X. S. L.Way ½ pt. Devi. 3° W. Vari. 8° W.
Course S. E. X. S. 38k. wind S. W. X. S. L.Way 0. Devi. 3° W. Vari. 8° W.
Course S. X. E. 44k. wind S. W. L.Way ¼ pt. Devi. 2° W. Vari. 8° W.
Course S. X. E. 35k. wind S. W. L.Way 0. Devi. 2° W. Vari. 8°W.

Give the Lat. and Long. IN, by the same method.

Answer—Lat. IN, 32° 36′ 0″ N. Long. IN, 65° 01′ 0″ W. Give the Course and Distance between St. David's Head, Bermuda, and the last Position, by Mercator Method.

Answer—True Course to Bermuda 127°, and Distance 24 miles.

Use the 360° Compass when putting down the True Courses in the Traverse Form.

L. A. T. 11h. 40m. A. M. Obs. Alt. Sun's L. L. 67° 23′ 45″ S. Cor. to Alt. plus 11′ 41″. Dec. corrected, 20° 10′ 6″ N. Lat. by D. R. 42° N. Give the Latitude by Tables 26-27 Bowditch.

Answer—42° 10′ 0″ N.

G. S. T. 28d. 11h. 14m. 07s. The True Alt. star Regulus 34° 13′ 02″ E. Star's Declination, 12° 22′ 12″ N. Lat. by D. R. 39° 40′ 00″ N. Star's R. A. 10h. 4m. 0s. E. Give the Long.

Answer—73° 5′ 0″ Long. W.

Left Diamond Shoals L. V. on a True Course 30° and had Hatteras abeam after sailing 4½ miles. Sailed until Hatteras bore, true, four points abaft the beam. Give the distance sailed from Hatteras abeam and Hatteras abaft the beam, and the distance from cruiser's position to Hatteras. Use the chart for this work.

Sailed from Diamond Shoals L. V. 32 miles, True course 30°. Give the Lat. and Long. IN. Took cross bearings at this time and secured the following: True bearing of Diamond Shoals L. V. 218° and True bearing of Hatteras 245°. Give the position of the cruiser by the cross bearings. Give the Lat. and Long. Make comparison on the chart of the two locations of cruiser as given.

Answer—Course and Distance 30° and 32 miles give Lat. 35° 32′ 00″ N. Long. in 74° 59′ 00″ W. By the cross bearings, Lat. in 35° 29′ 00″ N. and Long. in 74° 55′ 00″ W.

Give the Course and Distance between two places, A and B.

Lat., A, 39° 58′ 02″ N. and Long. 75° 16′ 39″ W. Lat., B, 36° 42′ 31″ N. and Long. 9° 11′ 10″ W. Using Mercator Method by Calculation.

Answer—True Diff. Lat. 196′ Mer. Diff. Lat. 248.3. True Diff. Long. 3965′.

Tang. of sum of logs. equals, Course S. 86° 25′ E. Sec. of Course and log. of True Diff. Lat. gives the log. for the Distance—3120 miles.

Give the Course and Distance between Overfalls Light Vessel, in Lat. 38° 47′ 57″ N. and Long. 75° 01′ 24″ W. and San Juan Light, in Lat. 18° 28′ 22″ N. and Long. 66° 07′ 57″ W. by Mercator Method and Calculation.

Answer—Course S. 20° 37′ 58″ E. Distance 1306.4 The log. of the Distance equals 3.11609. Find this in Table 42 Bowditch. You will find the first three figures of the Distance in the left hand column 130, and top of column of (log. 11594), the nearest log. 6. The small table to the right hand is used to get the exact quantity. The nearest log. found, to the log. wanted, is 11594 and the next greater log. is 11628, their difference is 34. The log we wish to find is 11609 and the next lesser is 11594, and their difference is 15. Now, find in the small table, the 34 at top of small column and run down that column until you find the 15. Fourteen is the nearest. Across this line, to the left, find the figure 4, which is the balance to add to the required Distance. It is a part of a mile, not 4 miles.

CORRECT THE FOLLOWING COMPASS COURSES TO TRUE COURSES, USING THE 360° CIRCLE

C. COURSES	DIST.	LEEWAY	DEVIATION	VARIATION
N. E.	20k	¼ pt. L.	20° W.	10° E.
N. E. X. E.	30	½ pt. R.	10° E.	9° W.
N. N. E.	10k	¾ pt. L.	5° W.	11° E.
EAST	60	1 pt. L.	1 pt. L.	2 pts. E.

From the True Courses find the Diff. Lat. and Dep., and then the Course and Distance Made Good.

Lay the True Courses on the Chart from Winter Quarter Shoals Light Vessel and give the Lat. and Long. by the Chart.

Give the Lat. and Long. IN, by Middle Latitude Method.

Answer—True courses 45°, 56°, 23°, 90°. Course Made Good—N. 68° E. Distance Made Good 108 miles.

Answer—Lat. IN, 28° 35′ 00″ N. Long. IN, 72° 48′ 22″ W.

Give the accurate Azimuth from the following: A. T. 2h. 47m. Lat. 33° 29′ N. Cor. Dec. 22° 14′ N.

Answer—True Azimuth, 96° 04′ 48″.

Give the Latitude—L. A. T. 2h. 9m. 23s. Cor. Dec. 23° 13′ 00″ N. True Alt. 57° 59′ 57″. Use the Single Altitude and Time Method.

Answer—39° 56′ 00″ N. Lat.

Lieutenant Horace Horner: Sailing the following True Courses from Winter Quarter Shoals Light Vessel. East 70 miles, E. S. E. 40 miles, S. E. 80 miles, West 120 miles. I will meet you in Lat. and Long. —? Would like to see your chart work and the Dead Reckoning. Give me your Deviation 2 P. M. of June 15. Let go your deep sea lead and give me the sounding just before you start on the West course. Bensen.

Answer—Assume any Compass Azimuth for the Deviation. The Lat. and Long. are to be taken from the chart and compared with the Dead Reckoning.

Set down the following True Courses and find their Diff. Lats. and Depts.

360° dist. 21 miles, 155° dist. 13, 25° dist. 13, 180° dist. 21, 90° dist. 5, 17° dist. 22. 163° dist. 12, 270° dist. 7, 90° dist. 7,163° dist. 9, 90° dist. 5, 360° dist. 21, 270° dist. 5, 90° dist. 10, 270° dist. 5,180° dist. 21, 90° dist. 8, 360° dist. 21, 90° dist. 8, 270° dist. 8, 180° dist. 11, 90° dist. 5, 270° dist. 5, 180° dist. 10, 90° dist. 8, 270° dist. 50 miles.

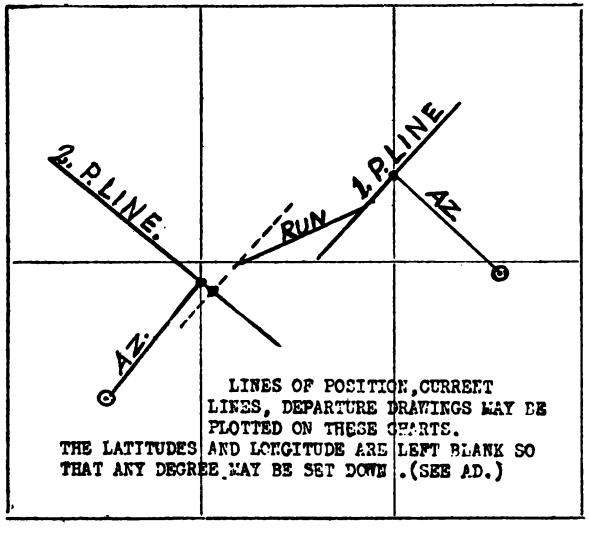
Answer—The Lats. and Depts. equal each other and the ship has returned to the place she started from. If you lay the courses and distances down on a chart of small scale, or a piece of paper that has a compass rose set true, you will find that the courses will show the letters MATE.

Set down the True Courses in the Traverse Form and secure the Diff. Lats. and Depts. from Table No. 1 of Bowditch.

S. E. X. S. dist. 29 miles, N. N. E. dist. 10, E. S. E. dist. 50, E. N. E. dist. 50, S. S. E. dist. 10, N. E. X. N. dist. 29, West dist. 25, S. S. E. dist. 10, W. S. W. ½ W. dist. 42, North dist. 110, E. ¾ N. dist. 62, North dist. 7, West dist. 62, North dist. 10, West dist. 8, South dist. 10, West dist. 62, South dist. 7, E. ¾ S. dist. 62, South dist. 110, W. N. W. ½ W. dist. 42, N. N. E. dist. 10, West dist. 25 miles.

Answer—The Diff. Lats. and Depts. equal each other and the ship has returned to her place of starting. If you will set down the courses True on a small scale chart they will make the figure of an achor.

CHART FOR SUMNER LINES



EX. Lat. D. R.....N. S. Lat. Obs.....N. S.
1 Long. D. R.....W. E. Long. Obs.....W. E.
Azi. 1st Line of Pos.....Run.....
2 Lat. Obs.....N. S. Long. Obs.....W. E.
Azi. 2nd Line of Pos.....
Azimuth Line ——o
1st Line of Pos. ————————
2nd Line of Pos.....
Return Line —·—·—·—·—·—

ANS Lat. 1st Pos.....N. S.
Long. 1st Pos.....W. E.
Lat. 2nd Pos.....N. S. } by Sumner Lines
Long. 2nd Pos.....W. E.

Scale—Lat. 5 miles ¼ in. Long. 6 miles ¼ in.

CORRECTIONS.

Page.

16. Continue to read from "Be sure to change this——time."
26. Table No. 6 "Ans. first example 17.3 Nautical miles."
29. Sixth line from bottom—174 equals 29 diff. x 6 is correct.
To find the number corresponding to log. follow this rule.
Rule—Find the first four numbers from Table 42.
Find the difference between the given log. and the next lower log.
Find the difference between the next lower log. to the given log. and the next greater log. to the given log. and divide the first difference by the second difference Now annex it to the four figures so far found. Don't add it. Carry out the division until you have enough figures to make the required numbers which the index will show.
39. The ninth example from top read to "ship in Long. 4 deg. 28 min. E." is correct.
40. The description of Mercator Chart should read—increases as we go North and would make the distance too large. Change it.
45. Under heading "Give the Latitude" ninth line down, end of line, should be Ans. S.
52. The tenth line from top should be Time before Noon 29 min. 34 sec.
53. Under-Rule—you may use the log. hav. instead of "Twice the Sine." Both are correct.
60. The sixth example should be Cor. W. T. 2 hr. 49 min. 00 sec.
Last example of page—G. T. July 5d. 3 hr. 20 min. 04 sec. is correct.
62. Second example under "Give Compass Course" Ans. W.S.W. ¼W. is correct.
68. Fifth example from top—Ans. 3 hr. 18 min. 41.33 sec. is correct.
98. Last Azimuth example—Ans. Dev. 16 deg. 23 min. W.
103. Answer to first example C. M. G. is S. 66 deg. E.
104. Drawing No. 2 is S. 66 deg. E.
118. Second line under Example—P. M. not R. M.
140. Second example cut out.
142. Second answer from bottom is 32 deg. 63 deg. 20 deg. 90 deg.
Last answer is Lat In, 38 deg. 35 min. 25 sec. N.
143. Last word of page is anchor.
Make the correction at once, so that when you try the examples you will not wonder why they do not correspond to your figures.

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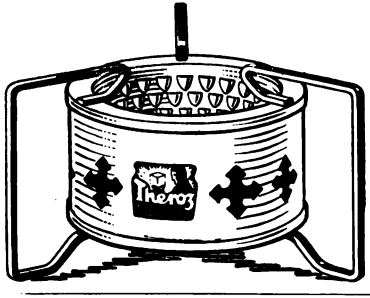

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